FEILDEN'S MAGAZINE

An

ENGINEERING REVIEW

Edited by C. EDGAR ALLEN.

Vol. 9. SEPTEMBER, 1903. No. 3.

Superheating by Wire-Drawing.

THE energy in a pound of steam (using the word in a broad sense) may be divided into—

(1) Pressure, or potential energy;
(2) Velocity, or kinetic energy; and
(3) Heat energy, due to its temperature and state, whether liquid or gaseous.

If the steam do no work on, nor exchange any heat with, external bodies, then the total amount of this energy will remain constant, however the pressure may vary. For instance, if high-pressure steam be wire-drawn down to a lower pressure, then the other two parts of its total energy must increase. If we further know that the velocity remains unaltered, then the heat energy must increase by exactly the same amount that the pressure energy decreases. Hence, if the original steam was wet, the increase of heat energy will have dried it somewhat, and if originally dry it will now be superheated.

Since the whole of the energy in the steam is due to the heat put into the original water, it becomes an easy matter to express the above facts in symbols. Thus, if—

u stand for velocity in feet per second;
L for latent heat;
h for sensible heat;
S for dryness fraction of the steam;
t for temperature of saturated steam at the given pressure;
T for the temperature of the superheated steam at the same pressure;
K for the mean specific heat of superheated steam between the given temperature limits; then—

$$S_1 L_1 + h_1 + \frac{u_1^2}{J2g} = \text{total energy} = S_2 L_2 + h_2 + \frac{u_2^2}{J2g}$$

where the suffixes 1 and 2 refer to the initial and final conditions, g being the value of the acceleration due to gravity, *i.e.* 32 ft. per sec. per sec. In the above case the steam is not superheated after wire-drawing; if it is superheated, then S_2 is unity, and we have—

$$S_1 L_1 + h_1 + \frac{u_1^2}{J2g} = L_2 + h_2 + \frac{u_2^2}{J2g} + K(T - t).$$

The expression is further simplified if, as is usually the case, the velocities u and u_2 are negligeably small.

This gives us a simple method of finding the original dryness of steam by wire-drawing it, and observing the amount of superheating which takes place. This is the principle of the wire-drawing calorimeter, shown diagramatically in Fig. 2.

Here a large vessel A, open to the atmosphere, is connected to a pressure-gauge for reading small differences of pressure, and to the steam-pipe with a throttling-valve on the connection. A thermometer inserted as shown in a pocket in A, filled with cylinder oil, reads the temperature T of the steam as superheated after the wire-drawing. The quantities L, h, and t are found by reference to steam

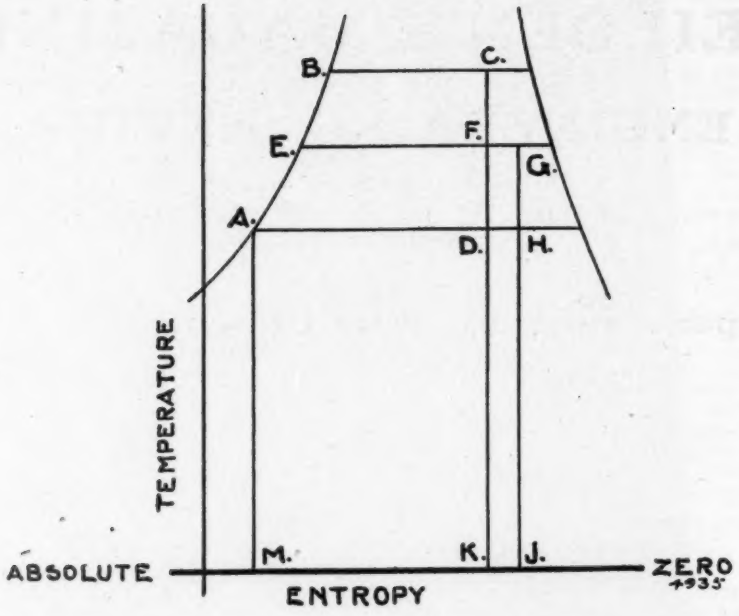

B.
C.
E.
F.
G.
A.
D.
H.
TEMPERATURE
M.
K.
J.
ABSOLUTE
ZERO
-493°
ENTROPY

FIG. 1.

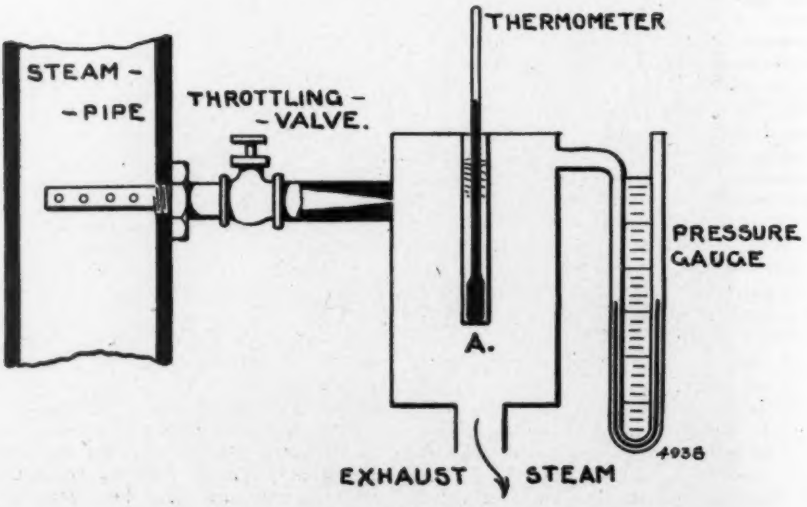

THERMOMETER
STEAM-
-PIPE
THROTTLING-
-VALVE.
PRESSURE
GAUGE
A.
4938
EXHAUST
STEAM

FIG. 2.

tables, the corresponding pressures being read off from the gauge on the steam-pipe, and that shown in the figure.

The value of such a piece of apparatus is doubtful. In the first place the steam will not be superheated at all if it is very wet to begin with. Then, again, we have the difficulty of obtaining a fair sample of steam. To do so the drawing-off pipe projects into the centre of the steam pipe; but it is highly probable that if the steam is wet it will deposit much of its moisture on the steam-pipe sides, and hence this will not be taken into account by the wire-drawing apparatus. The chamber A has to be fairly large in order to keep the velocity very small. Radiation also very seriously affects the results.

The most serious objection to this method, however, lies in the fact that the value of K, the specific heat of superheated steam, is not yet definitely known. A series of careful experiments by Dr. Grindley showed that it was independent of the pressure, but increased with the temperature, varying, in fact, from about ·57 at 300 degs. Fahr. to about ·7 at 420 degs. Fahr. Dr. Grindley's experiments, moreover, seemed to show that dry, saturated steam, as used by Regnault in his classical work on steam, really contained a small quantity of moisture which could not be freed from the steam by ordinary separator methods, but which required heat to evaporate it before any superheating at all took place. Professor Callendar, using an absolute method, however, finds that the specific heat decreases with an increase in temperature.

As many people have an exaggerated notion as to the amount of superheating that wire-drawing can do, we will take an example. Suppose steam which is 97 per cent. dry at 250 lbs. per sq. in. to be wire-drawn to 200 lbs. per sq. in. Then from our first formula (neglecting the velocity terms) we see that after wire-drawing the steam is only 97·8 per cent. dry, and is not in the least superheated. The amount of drying that can be obtained by wire-drawing the steam through a few pounds, as is sometimes done, is negligeable. Wire-drawing not merely does very little to dry the steam, but it renders it less efficient for use in a steam engine. The amount of work which can be got out of a pound of steam depends on the highest and lowest temperatures used. The lowest temperature is fixed by the exhaust, and hence the efficiency will be greater the higher the upper limit of temperature. Wire-drawing reduces this and offers no adequate compensation.

This is clearly shown by the entropy diagram (Fig. 1), the use of which enables one to clearly understand many steam problems. Thus, if AD represents the lowest or exhaust temperature, BC the original highest temperature, and EG the highest temperature after wire-drawing, we have that the area $A\,B\,C\,D$ represents the amount of work which can be obtained from 1 lb. of the original steam. The area $A\,E\,G\,H$ represents the amount of work which can be obtained from 1 lb. of the wire-drawn steam. But the total area MA, BC, K must be equal to area $M\,A\,E\,G\,J$, hence the area $E\,B\,C\,F$ equals the area $F\,G\,J\,K$; so that evidently less work can be obtained from the wire-drawn steam than from the original steam, and even this difference is accentuated in practice.

Another method of superheating steam by wire-drawing has been suggested by Professor Wilkinson, which depends on the fact that when steam expands freely without doing external work, then the energy which would in other circumstances have appeared on the piston of the engine now appears as velocity, or kinetic energy in the steam.

The steam in expanding does work in the one case on the piston of the engine, in the other case it does the same amount of work on itself, this work being spent in increasing the kinetic energy of the steam. The phrase "does work on itself" is used in the sense that neighbouring particles of a given mass of steam do work on one another, any one individual particle being incapable by itself of increasing its own kinetic energy. I know that Professor Smith dissents from this view, but it is capable of what seems to the writer to be a clear mathematical proof, and is further strongly supported by Mr. Rosenhain's experiments.

Under these circumstances the steam will follow the ordinary law of adiabatic expansion as to pressure, dryness, etc. Hence, as the pressure falls the velocity will increase and the steam will get wetter. If now, when the steam has been fully expanded, the moisture could by some means be withdrawn from the steam without reducing the velocity, then, having withdrawn the moisture, if the velocity be reduced to zero the kinetic energy will be converted into heat energy, and since all the moisture has been withdrawn the whole of this heat will be spent in superheating the steam.

For example, if dry saturated steam at 215 lbs. per sq. in. absolute be expanded freely to 1 lb. per sq. in. absolute, it will then contain 24 per cent. of moisture, and have (including the moisture) a velocity of 4,120 ft. per second. If now the moisture be withdrawn it will take away its portion of kinetic energy and its own heat energy. If the velocity of the remaining steam be arrested 258 B.T.U. will be liberated, and if the mean specific heat of the superheated steam be taken as ·5 the steam will be superheated 680 degs. Fahr., raising its temperature to 782 degs. Fahr. If, on the other hand, the moisture is not abstracted, then the first work of the liberated heat is to evaporate this moisture. This takes 251 B.T.U., leaving 89 B.T.U. for superheating, which will superheat it 178 degs. Fahr., raising its temperature to 280 degs. Fahr. Owing to internal friction these high velocities can never be fully attained. As to how he would abstract the moisture Professor Wilkinson does not say. Some might be got out by means of a centrifugal separator, for it must be remembered that the moisture must be abstracted before the velocity is arrested.

Even if this method prove practicable it is not likely to come into general use.

FRANK FOSTER.

Mistaken Ideas with reference to the Resultant Force and the Maximum Pressure in Retaining Wall Calculations.

THERE appears to prevail among a large number of practical engineers (many capital men who have not had the time and opportunities for any great amount of theoretical education), with whom I have come in contact, a rather confused idea as to the meaning of the normal component of the resultant force, and the maximum pressure when applied to retaining walls.

I venture to offer a useful, and what is considered by many for whom I have cleared away this little difficulty, a simple illustration of the same.

I am fully aware that for the mathematician the illustration is not required, but there is a large body of clever, practical men who have not the time to spend solving what is for the moment a knotty problem, and who are therefore only too pleased to avail themselves of a simple illustration.

To those readers and students of your valuable paper I submit the following :—

Take for the purposes of illustration a simple form of retaining wall of the profile shown in Fig. 1.

I find that the greatest confusion appears to prevail in the case of the normal component P of the resultant force R, and the opposing pressures, $A\,B$, $E\,F$, $H\,I$....

The forces (*i.e.* $A\,B'$, $E\,F'$, etc., resulting from the combined weight of the wall and the thrust on the wall) which cause the reactionary forces or opposing pressures, $A\,B$, $E\,F$.. can be represented by one force, P, which is then called the resultant of those forces, and it will be seen by reference to figure No. 1 is the normal component P of the resultant force R.

That this force P can replace the forces $A\,B'$, $E\,F'$... will be shown further on.

Assume that the resultant R has been found to act at the outside edge of the middle third, then the normal component P of R will also act at that point.

In this position the forces range from zero at C, the back edge of the wall, to a maximum at A, the front edge, and consequently may be shown as a triangle $A\,B'\,C$, each vertical ($A\,B'$, $E\,F'$...) of which represents a force which causes a reactionary force or opposing pressure in the foundation, and therefore a similar triangle may be plotted below to represent these opposing pressures.

Now the usual formula for arriving at the maximum pressure at A is

$$\text{Maximum pressure} = \frac{2\,P}{3\,d}.$$

P = normal component of resultant R, and is also the resultant of all the normal or vertical forces acting along $A\,C$.

d = distance from A, or outer edge of wall, to the point where the resultant R is found to act, equal in this case to $\frac{A\,C}{3}$.

Now, as $A\,B$ can be drawn to scale to represent the maximum pressure, I find a large number of engineers jump to the conclusion that therefore $H\,I$ represents the force P plotted to the same scale; but this is *not* so, as I shall endeavour to explain later. Unfortunately this mistake is only too prevalent, and errs on the side of weakness when calculating the maximum pressure the footings or concrete foundation have to support. To illustrate the above formula, assume the line of joint $A\,C$ to represent a bar or rod $A\,C$, Fig. 2, and replace the forces $A\,B'$, $E\,F'$... by, say, half-a-dozen children of various ages, from about 12 years to 7 years, and varying in strength from a good strong, sturdy lad, No. 1, down to a practically negligible effort put forward by No. 6; also replace the pressures $A\,B$, $E\,F$...

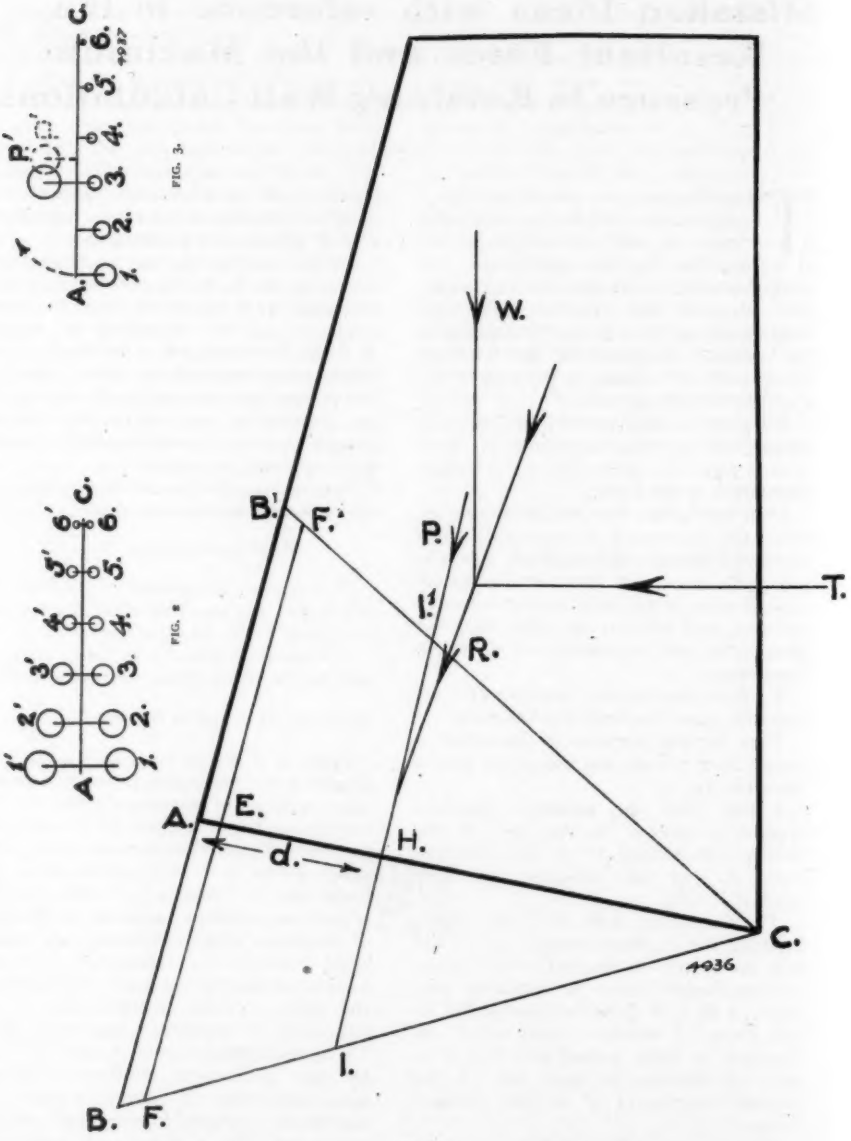


FIG. 1.

W = Weight of Wall.
T = Thrust of Backing.
R = Resultant.
P = Normal component of R.

AB, EF, HI = Ordinates of Triangle ABC.
AB', EF', HI' = " " $AB'C$.
d = Distance from A to H.

opposed to these forces by six other children, each opposing child of equal strength.

Then we have a living example of what is taking place in Fig. 1.

Now, for the children representing the forces $A\,B'$, $E\,F'$, substitute a full-grown man, P', Fig. 3.

If the man were to hold the rod in the centre, as shown by the dotted position in Fig. 3, it would have a tendency to turn in the direction shown by the arrow at the end A, and the man would have some difficulty in keeping it balanced against the combined effort of the strongest children; but if he shifted his position towards A he would eventually come to a point just where the children on opposite sides of him balanced each other.

Here we have a single force P' (the man) equal to the sum of the forces 1′, 2′, 3′, 4′, 5′ and 6′ (the children), and replacing them with the same effect. The point at which this single force P' is found to balance the opposing forces 1, 2, 3, 4, 5 and 6 is opposite child No. 3, or the outer edge of the middle third of the rod, if the children are split up into three divisions of two in each.

As P' corresponds to P in Fig. 1, and the children were assumed to represent the forces $A\,B'$, $E\,F'$... therefore force P is equal to the sum of the forces $A\,B'$, $E\,F'$... and will act as found at the outer edge of the middle third; but as $A\,B'$, $E\,F'$... are equal and opposite to $A\,B$, $E\,F$ therefore force P is also equal and opposite to forces $A\,B$, $E\,F$... or what amounts to the same thing, the area of the triangle $A\,B\,C$. Referring to Fig. 3 again, as the effort by the man is now known to equal the combined effort of the children it is quite clear that the child No. 3, who is opposite the man, does not exert the same effort as he does, or else with the combined effort of the other children the man would be pushed over.

Similarly, then, the pressure $H\,I$, Fig. 1, which corresponds to the child No. 3, Fig. 3, does not represent the force P for the same reasons, and that it is only a part of the triangle $A\,B\,C$, which we have just proved is equal in area to force P.

Wnat $H\,I$ does represent is the pressure at that point caused by the force $H\,I'$ at that point, which cannot be the resultant force P so long as the wall remains there.

$H\,I$ exerts the same force in opposition to $H\,I'$ as child No. 3 does to resist the pressure of child No. 3′ in Fig. 2.

As we have found P to be equal to the area $A\,B\,C$ we can find the maximum pressure from the following:—

$$P = \frac{A\,C \times A\,B}{2} = \text{area of } A\,B\,C$$

$$\therefore A\,B \times A\,C = 2\,P$$

$$\therefore \quad A\,B = \frac{2\,P}{A\,C} \text{ or } \frac{2\,P}{\frac{A\,C}{3}} \text{ or } \frac{2\,P}{3\,d}$$

And as $A\,B$ is drawn to represent the maximum pressure in Fig. 1 then maximum pressure $= \frac{2\,P}{3\,d}$.

Of course it is quite an easy matter to substitute a man for six children in the case of the illustration, but, as stated above, it is impossible to substitute a concentrated force for the retaining wall, and therefore the chief reason for finding the resultant is for the purposes of calculation; and this point requires to be carefully kept in mind.

It is not the resultant which has to be resisted, but a number of forces equal in sum to the resultant and distributed over line $A\,C$ with increasing intensity from zero at C until the maximum is reached at A.

If authors of text-books would attempt to put matters in as simple a light as possible, or in the clear manner of Prof. Perry's text-books, it would greatly encourage a large number of engineers who get disheartened with a number of present-day publications, written as they are more for a man with a sound mathematical training.

J. S. D. MOFFET, A.M.I.Mech.E.

The Viaur Railway Bridge.

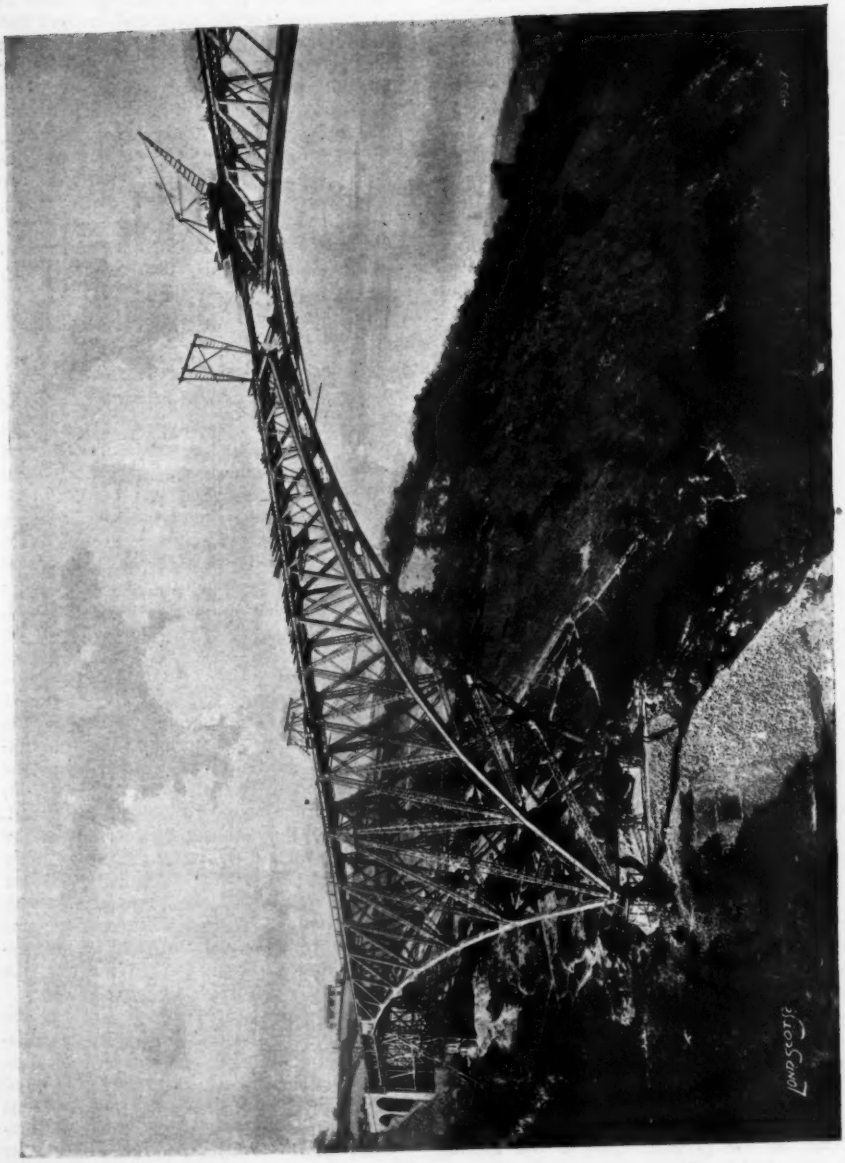
THE River Viaur, which forms the boundary between the French Departments of Tarn and Aveyron, also constituted that between the French possessions and the territory occupied by the English, as determined by the Treaty of Brétigny in 1360. Moreover, the Viaur valley, which is in places nearly 200 m. (656 ft.) deep, also constituted the most serious obstacle to making the line between Carmaux and Rodez, forming part of M. de Freycinet's great scheme. The project for bridging this valley was definitely adopted in 1889; the first stone was laid in 1895; the articulated crown was put in on July 1st, 1902, and the bridge was opened on October 5th last by the Minister of Public Works, who then declared that the first conception and the realisation of this work were due to M. Paul Bodin, professor at the École Centrale, and this year president of the Société des Ingénieurs Civils de France.

The principle of the bridge is that of balanced beams, and consists in adding to the central arch, for relieving the pressure exerted at the point where the two constituent half-arch elements unite, corbellings or counter-bays, which, by the mere effect of their weight, balance the whole structure, and especially compensate the thrust of the two half-arches at the crown. In other words, they cause each of these beams to act like a steelyard, which would otherwise dip towards the middle of the central span. In this manner the bridge is rendered independent of the two river banks between which it affords communication; and it possesses inherent bearing points at the springing of each frame composing the central bay and at the articulated joint in which they meet. In fact, the bridge does not bear on one or other of the shores to which it affords access, owing to the connecting bays, independent of the general structure, and so arranged that they lend themselves to all the deflections of the central arch and the play of its articulations under the influence of load and contraction or expansion.

The two symmetrical frames, or beams, which compose this central arch bear against one another by means of an articulated crown in the middle of the arch, and rest on masonry supports by means of shoes, also articulated, on either side. Again, each of these frames is constituted by two longitudinal members having a side batter of 1 in 4, so that the horizontal distance between the centre lines of these two members, which at the crown of the arch is less than 6 m. (say 19 ft.), attains 33·4 m. (say 111 ft.) at the main abutment level. These members, connected together by vertical trusses and horizontal cross-stays, carry the platform, whose greatest height above the valley is 116 m. (380 ft.).

The total length of the bridge proper from bank to bank is 460 m. (503 yds.); and the approach abutments are 21 m. (23 yds.) long on the Carmaux and 29 m. (31½ yds.) on the Rodez side. The distance between the two outside or shore abutments, which carry the connecting bays, small bridges composed of lattice girders, is 410 m. (448 yds.), comprising 95 m. for each of the counter-bays, and 220 m. for the central arch.

As the central span, though reduced from the 250 m. originally intended, is actually 220 m. (721 ft.), with a rise of 53·73 m. (say 176 ft.), it greatly exceeds that of the Garabit viaduct, which is only 165 m. (541 ft.); and its special feature is that the two halves bear against one another by means of an articulated key in the middle, while at each side they rest upon masonry piers by means of shoes which are also articulated—an arrangement very analogous to that adopted for the roof of the Paris Galerie des Machines. In the first place a large timber scaffolding was put up on the Carmaux side, landwards of the bearing points of the central arch, for erecting the counter-bay, supported, as it advanced, by tem-



THE VIAUR VIADUCT: HALF OF THE MAIN BAY WITH COUNTER-BAY ON THE CARMAUX SIDE.

porary timber piers. This scaffolding was afterwards taken down and re-erected on the Rodez side for effecting the same work, during which time the half-arch on the Carmaux side was put up from the bearing points on one of the main abutments to the middle of the span. For accomplishing this work, at the upper part of the counter-bay already constructed, two horizontal beams, with their ends firmly anchored in the ground, were put out for 20 m. (65½ ft.) in advance of the portion of the bridge already terminated; and on this overhanging stage a line of way was laid carrying a truck, from which was hung a flying scaffold constituting an enormous cage with several decks, like that used for winding in mines. A 5-ton steering crane, erected on the staging behind the truck, permitted the delivery, on the various cage decks, of the pieces of the bridge, which the workmen put in place. The whole of the flying scaffold was pushed forward into space, *pari passû* with the erection of the half-arch put out to meet that of the opposite bank, where the same method of erection was employed. For keeping in place each half-arch during its erection, while overhanging, the ends of the portions completed were securely moored by steel-wire guy ropes to enormous blocks of masonry.

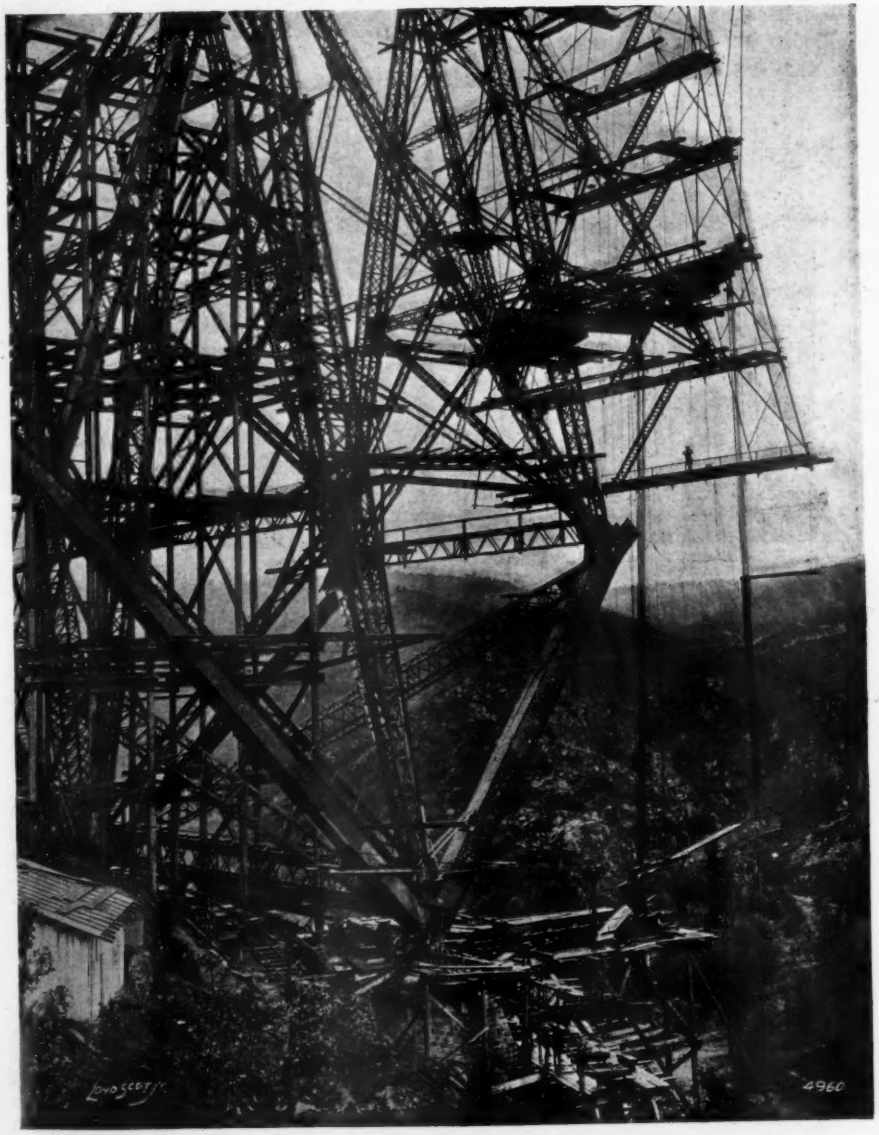
History of the Bridge.

On account of the exceptional importance of this bridge, the Administration of the Ponts et Chaussées, in accordance with the Companie du Midi, instituted a competition among French constructors who had already successfully erected important works. Seven projects were sent in and examined by a special commission, which eventually selected the design, entirely of metal, submitted by the Société de Construction des Batignolles. The Minister of Public Works adopted the report of the commission, and sent the constructing company a written order for the bridge on 30th August, 1889. Some modifications in the specification, however, demanded by the Company when sending in the project, delayed the getting out of the definite design, which was submitted in September, 1892. In the meantime the government regulations as to the construction of metal bridges had been modified; and the administration then enjoined the constructing Company to send in drawings in accordance with the modifications. When this new design was submitted, an advantage was found, as regards the quantity of material required, in reducing the span of the central arch from 250 m. to 220 m. (721 ft.), while correspondingly increasing the rise. On this modification being adopted, a fresh design was submitted in January, 1895, and adopted in April, 1896, when the company was authorized to get out the detail drawings.

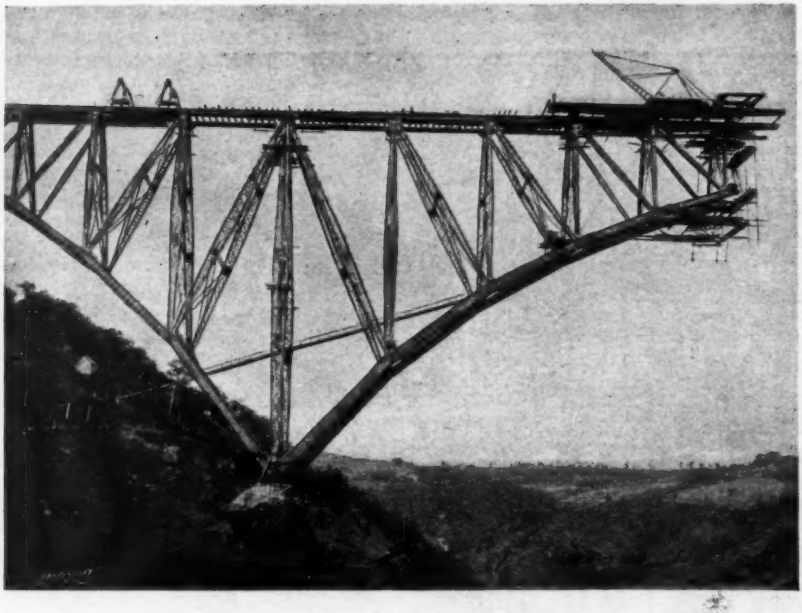
General Conditions.

Given the section of the valley to be bridged, a metal arch appeared to meet all requirements; but a single arch for the whole span would set up great lateral thrust and consequently require a considerable weight of metal, while its alteration of form owing to variations of temperature must necessarily give rise to great additional strains, and consequently to a still further increase in the weight of metal required, besides which, the erection of such an arch appeared very difficult. In order to diminish the thrust, to avoid the additional strains and facilitate erection, a central arch was adopted, continued on either side of its springing by counter-bays, so intimately connected with the central bay as to form one with it, thus counter-balancing part of the thrust, while at the same time permitting the erection with overhang of the central arch, balanced by the efforts brought to bear at the ends of the counter-spans. With the same object the central arch was divided into two equal parts by an articulated joint in the middle of the bay, the ends of the counter-bays being left free.

By arranging articulated joints at the springings, as at the crown, the calculations were simplified, and could be made without resorting to formulæ connected with deflection, since all the reactions would pass through fixed points. Moreover, variations of temperature would exert no action on the strength of the metal; and the horizontal thrust could, at the



THE VIAUR VIADUCT: PUTTING UP THE LOWER RIB OF THE SECOND PANEL IN THE MAIN BAY.



THE VIAUR VIADUCT: OVERHANG OF THE MAIN BAY.

moment of keying the central span, be reduced to exactly the effort resulting from the preponderance of weight in the central span over that of the counter-bays and the reaction of the connecting bays.

The conditions of the project were determined by the above considerations; and the spans were fixed empirically. It was, in fact, necessary to balance the bays so as obtain a minimum of weight, and also in such a manner that, in the most unfavourable positions of the load, account being taken of the wind's force, the thrust at the crown would be always positive, and have a sufficient value to ensure the two half bays being always in contact. By way of additional precaution, tie-rods, embracing the central articulation pivot, were attached to the end of each half-frame; and with the same object powerful anchoring rods attached the metal framework to the bearing points at the springings of the arch.

Between the ends of the counter-bays and the masonry approaches are connecting bays, bearing at one end on the counter-bays and at the other on the shore abutments, the object of which arrangement is to permit a vertical and horizontal displacement of the ends of the counter-bays under the action of wind and load, and especially under that of variations in temperature. With this object the girders of these connecting bays rest on bearing-plates permitting movement round the horizontal or the vertical axis, and also longitudinal movements due to contraction and expansion.

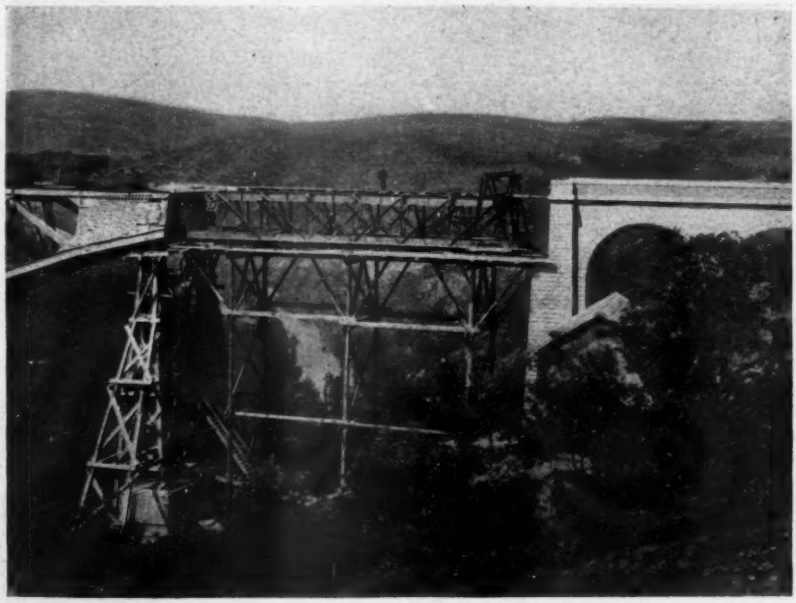
Description of the Structure.

In order to give sufficient rigidity to the elements constituting the arch, they are made in the form of frames, whose height increases from the crown on one side, and from the ends of the counter-bays on the other, to the springings, thus realising a very rigid arrangement on account of the great value of the moments of inertia.

Each half-frame consists of an upper rectilineal rib and of a lower polygonal rib, both of them constituted by box girders placed end to end; and they are connected together by vertical members (in the transverse direction) and also by oblique members, the whole constituting the tympans, while the centre lines of the members entering into the composition of the frame and terminating in one and the same "knot," or juncture, meet at the same point.

The main abutments, carrying the articulated joints at the springings of the two main frames, are each composed of two masses of masonry symmetrical with respect to the central plan of the bridge, the distance between their centre lines being 33·4 m. (nearly 110 ft.). These masses of rectangular section, built of ashlar-dressed stone, are each surmounted by three courses of tooled granite, with surfaces decreasing in the upward direction. The object of this arrangement is to transmit the load on the ashlar masonry over a larger surface, and thus diminish the pressure per unit of surface supported by the masonry. The outside stones of one and the same granite course are connected together by iron cramps run in with lead; and some stones of the lower course project into the ashlar masonry, in the form of tenons, for preventing any movement. The ashlar masonry is also splayed out with a batter that varies with the faces. Each abutment contains an anchorage chamber, with approach. The anchorage-rod, passing through the mass of masonry, has at its lower end a nut, which is surmounted by a wrought-iron beam, bearing on a cross-beam of double-T section bedded in the masonry.

The upper ribs have two webs, and show in cross-section the form of a letter U reversed. The upper flange, which has a uniform width of 1·1 m. (3 ft. 7 ins.) and a thickness of 10 mm. ($\frac{3}{8}$ in. full), is connected to the webs by four angle bars 100 by 100

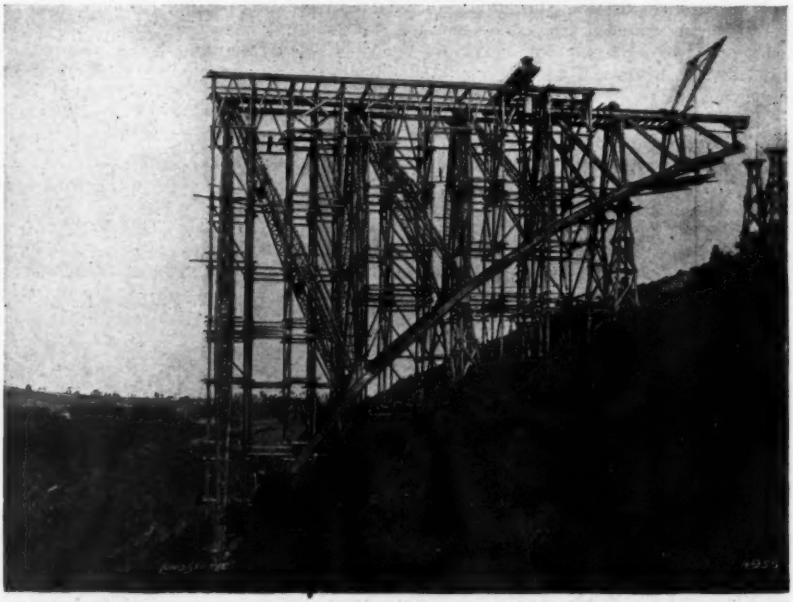


THE VIAUR VIADUCT: ERECTION OF A CONNECTING BAY.

by 12 mm. (4 ins. by 4 ins. by ½ in.). These webs, which have a uniform thickness of 12 mm. (½ in.), are spaced 80 cm. (2 ft. 7½ ins.) between their inner faces; and their height varies progressively from 0·49 m. (1 ft. 7¼ ins.) to 0·789 m. (2 ft. 7 ins.), this maximum being attained above the articulations of the springings, and the minimum at the crown and the ends of the counter-bays.

The lower ribs are constituted like the upper, but with this difference, that their flange, sometimes built up of several thicknesses of plate, is at the bottom; and in elevation these ribs take a polygonal form, the straight portions being connected by circle arcs of 10 m. (33 ft.) radius. For preventing deflection in the various straight parts of the ribs, some of them have been strengthened over a great portion of their length by the addition of an upper flange, transforming the element into a box girder.

In each half-frame the space between the approximately vertical members diminishes from the springings to the crown of the arch and to the ends of the counter-bays, varying from 16·2 m. (53 ft. 1½ in.) at the springings to 7·2 m. (23 ft. 7½ ins.) at the crown of the arch, and 6·3 m. (20 ft. 8 ins.) at the ends of the counter-bays. The vertical and oblique members, constituted in the same manner, belong to two different types, according to their length, the shorter being of double-T section and the others of box section. For preventing deflection, the oblique members and the verticals (in the transverse direction) of a certain length are increased in width at their middle in the longitudinal plane of the frame; but there was no occasion to increase their width in the transverse direction, because the parts opposite one another in the two frames are connected



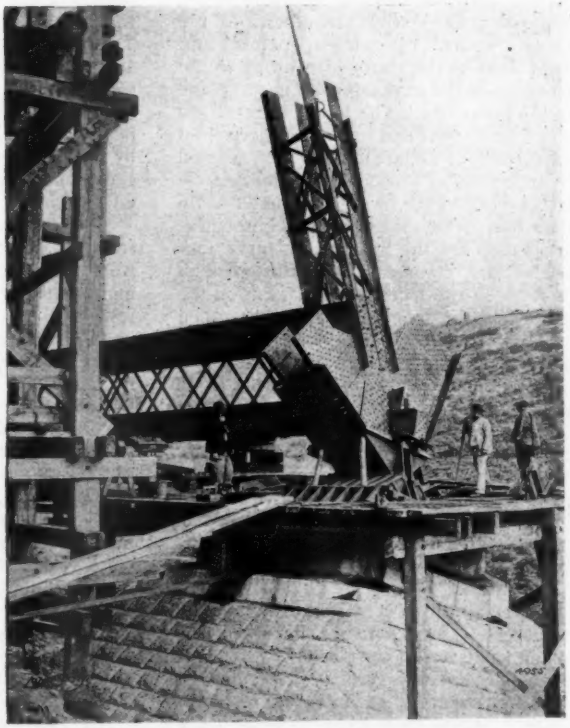
THE VIAUR VIADUCT: ERECTION OF COUNTER-BAY ON THE RODEZ SIDE.

by cross-stays, which arrangement prevents any tendency to deformation. The oblique members, subject only to tensile strain, have also been increased in width at their middle, in order to stiffen them, so as to resist any vibration which might be set up, and also for enabling them the better to withstand the action of their own weight.

The members near the springings of the arch are the longest; and a vertical projection of the approximately vertical member above each articulation of the springings shows a height of about 55 m. (180 ft.), corresponding with a greater actual length. These long vertical members, which have to withstand considerable strain, are made up of four angle bars, strengthened or not by flat bars; and the four angles are connected together by flat and channel bar diagonals.

The vertical members are fastened to the out side of the webs of the ribs by their angle bars; and the oblique members have, on the contrary, their angle bars placed inside the webs of the ribs. Where the "knots," or junction points, occur, the webs of the ribs have been widened out to the form of gussets, in order to afford sufficient room for getting in the number of rivets necessary to connect the vertical and oblique member with the rib.

The lower "knot," or junction point, of the longest vertical member, which coincides with the articulated joint of the springings, constitutes the base on which the half-frame reposes. The webs of the ribs of the central arch and of the counter-bays meet at these points, and are cut up into steps for being connected with the gussets constituting the "knot"; and these gussets, made up of several thicknesses of plate, are stiffened by frames. The "knot" comprises, for each web, four 12-mm. (say ½-in.) plates, one of which forms a cover plate; and all the pieces of the "knot" are connected together on the gussets, strong steel plates in the form of a right-angle triangle ensuring the rigidity of the construction at this point. The vertical members near the crown of the central span, enlarged for constituting full panels, are strengthened for receiving, on



THE VIAUR VIADUCT: "KNOT," OR JUNCTION POINT, OF ARCH AND LOWER CROSS-STAY.

the bearing shoes, the plates containing the articulation axis; and with this object the webs are formed of several thicknesses of plate, being further stiffened by steel frames and angle plates, for ensuring the perfect transmission of the frame strains to the articulation axis at the crown.

The strains due to the wind's action on the whole metal structure are transmitted, by means of horizontal cross-stays and vertical diagonal stays in the plane of the approximately vertical members, to the lower "knots," or junction points, and from them to the abutments, owing to the presence of the stays arranged in the plane of the lower ribs. The lower "knots" are connected two and two by horizontal cross-stays of rectangular section, formed by four parallel angle bars, connected by lattice-work in the form of the letter V on their four faces. Between two consecutive cross-stays are the stays, made up of four angle bars, connected by lattice-work of V form on two faces, and X form on the other two, the longest bars being swollen on their four faces. The horizontal cross-stays and those between the vertical and oblique members are constituted by angle or channel bars suitably stayed together; and these bars are attached to the frames by gussets. The horizontal cross-stays, which connect together the lower "knots," or junction points, and which have to stand great strain on account of variations in temperature, are veritable beams, or girders, composed of two U-ribs connected by lattice-work.

The platform is constituted by its main transverse girders, situated in the vertical plane (transverse as regards the bridge) of the approximately vertical members, and therefore spaced at unequal distances apart. These transverse girders carry two large longitudinals, which are themselves veritable girder bridges, whose length is equal to the distance between two successive vertical members. The longitudinals are stayed by flat bars, and connected by secondary transverse joists, which latter carry two secondary longitudinals that support the track. The main transverse girders of the bridge have a single or a double web according as the vertical members to the upper portion of which they are connected are themselves of double-T or of box section. The height of the main longitudinals, which all have a single solid web, varies between 80 cm. (2 ft. 7½ ins.) and 140 cm. (4 ft. 7½ ins.). The rails are laid on longitudinal sleepers, kept in place by angle-plates and straps.

The track is straight and also level, except that it is slightly raised at the middle of the central span, so that the line shall not appear concave at the crown. The platform is completed by a remarkably strong parapet, which consists of a solid plate girder, 1·8 m. (6 ft.) high, riveted to the upper ribs of the frames, or beams, strengthened at frequent intervals by buttresses, and capable of resisting the shock of a train in the event of its running off the rails.

The connecting bays are formed by straight girders with single lattice-work web, characterised, like the frames of the main bay, by complete symmetry (with respect to the median plane) of all the parts entering into their composition. These girders, suitably stayed, are connected, where the vertical members occur, by the transverse joists which carry the longitudinal sleepers. These connecting bays rest on the cross-stay at the end of the counter-bay, with the intervention of bearing-pieces, the form of which is that of a cylinder with vertical axis and slight height, engaging with easy play in concave parts of corresponding form. The bearing on the shore abutment is constituted by an appliance provided with expansion rollers, and upper plate carrying a horizontal articulation the axis of which is perpendicular to the plane of the girders.

The bearing arrangements of the frames differ from those generally employed, because the shoes are not horizontal, and bearing beams are arranged along two planes, one horizontal and the other inclined, and lastly, because they are fitted with two sets of adjustment wedges. Each bearing appliance comprises four main parts — a cast-iron beam, a bearing-plate, and two cast-steel supports for the articulated joint. The lower support rests on the cast-iron beam

with the cast-steel bearing-plates, and six forged steel adjusting wedges. Between the wedges and the cast-iron beam additional wrought-iron packing pieces are interposed, when necessary, in order to permit of raising or lowering the bearing-plate on the beam. Between the bearing-plate and the edges of the cast-iron beam there are other wedges, which permit of sliding the plate over the beam. These arrangements permitted of bringing the axes of the two parts of the work perfectly opposite one another when the "knots," or junction-points, of the springings were put in place. The articulated joint proper is constituted by cylindrical surfaces of 36 cm. (14½ ins.) radius; and the upper articulation support terminates in a plate 5 cm. (2 ins.) thick, on which rests the above-mentioned shoe, a sheet of lead 5 mm. ($\frac{3}{16}$ in.) thick being interposed between the two.

The articulated joint at the crown is constituted by a horizontal forged and turned steel cylinder 95 cm. (3 ft. 1½ in.) long and 20 cm. (8 ins.) in diameter, terminated at each end by flanges, or collars, of 30 cm. (12 ins.) diameter, for preventing lateral displacement.

The mild-steel bars, angles, etc., produced at the Creuzot, Denain, and Pompey works, were machined at the Paris works of the Société de Construction des Batignolles, so that they arrived on the spot ready for being put in position.

Erection of Metal Portion.

Not far from the erecting yard a space had been levelled so as to be nearly horizontal, on which a half frame was set out full size, as also were the cross and diagonal stays. It was then possible to put the different pieces together and enlarge all the rivet holes by reaming. The various lengths (or sections) of bars were then riveted up, their length being generally kept from 5 to 8 metres (16 to 26 ft.), and their weight within 4 tons, for preventing difficulty in erection.

The scaffolding for the erection of the counter-bays extended almost entirely over the ground area under the metal portion to be constructed, being intended to furnish the bearing or anchoring points necessary for raising the parts and putting them in place. This scaffolding presented in elevation a length of 73·6 m. (240 ft.); and its height varied from 26 m. (85 ft.) to 64 m. (210 ft.). It consisted of five pylons, or pyramidal piers, coinciding with the "knots," or junction points, of the lower rib of the counter-bay, these piers being only connected at their tops. The greatest width at the base of this scaffolding attained 32·5 m. (106½ ft.); and the upper part received a travelling truck, which carried crab-winches with horizontal travel at right angles to the line of way.

The erection was begun by putting in position the two vertical members immediately over the abutment, which afford connection between the articulated joint of the springing and the upper rib. At the same time the lower cross-stay connecting these two parts at their base was put in, as also the main transverse girder of the bridge effecting their connection above, while concurrently the diagonal stay in the plane of the vertical members was naturally placed in position. It was then possible to erect the lower ribs of the first panel of the counter-bay and their diagonal stay, as also the first oblique members of the two frames, with the corresponding cross and diagonal stays. The panel was completed by putting up the first vertical members and the upper ribs, the same operations being effected in the same order for the erection of the other panels. At the time the oblique members of the first panel were put in and riveted, a timber pylon, or pier, was formed at the end of this panel, and under each frame, for supporting the end of the portion erected, similar piers being formed in succession as the erection proceeded. Lastly, after the whole counter-bay was completed, two other pylons were formed in the same manner at the end of this latter, which permitted of taking down the scaffolding and putting it up on the other bank.

Immediately after completion of the first counter-bay, erection of the central bay was begun, the work proceeding with overhang, *i.e.* without being supported underneath; and with this object

a wrought-iron frame, to which the name of *baleine* (whale) has been given, was arranged on the first panel of the counter-bay. This frame consists essentially of two steel beams, slightly longer than the collective lengths of the pieces entering into the composition of the first panel of the counter-bay and of the first panel of the central span. The distance between their inside faces is a little greater than the outside width of the upper part of the main frames; and these two longitudinals were stayed by two transverse beams. On the *baleine* was arranged a platform with track, the rails of which were laid in line with the beams of the *baleine*. The line of way carried a platform supporting a steering crane, sufficiently powerful to lift most of the lengths (or sections) constituting the vertical and oblique members of the central bay. There also ran on this line of way a travelling carriage, or truck, from which was suspended a vertical latticework tower having five decks, and sufficiently deep to permit of reaching the first "knot" (or junction point) of the central bay counting from the abutment, this carriage being movable along the whole length of the bridge. Access to the five decks, each of which had a width slightly greater than that of the work, was rendered easy by a fixed timber staircase.

For putting up the first panel the beams of the "whale" were placed above the first panel of the counter-bay, one of the cross-stays being then situated above the abutment vertical member, and the other cross-stay being in line with the first vertical member of the counter-bay. Under these circumstances the outside end of the "whale" overhung by a length slightly greater than that of the first panel of the central bay. Of course, the inside or hind end of the "whale" was firmly secured to the first vertical member of the counter bay; and the lattice-work carrying the five decks was then put up at the end of the "whale," as also the steering crane.

The first panel was erected in the following manner:—The upper length (or section) of each of the two oblique members was first put in place, and then the succeeding length (or section), while at the same time the horizontal cross-stays and the diagonal stays in the plane of the vertical and oblique members of the two half-frames were put in. The positions of the oblique members were, moreover, regulated with respect to the vertical members, during erection, by means of temporary rods, each end of which was fastened to the vertical and to the oblique members. At the same time that the oblique member was put up, the pieces of the lower ribs of the first panel were put together and riveted up on the ground. Each of these ribs, weighing about 42 tons, which was naturally put together at the nearest possible spot to its definite situation, was lifted in a single piece by crab-winches and pulley-blocks, suitably arranged. After the lower rib was connected with the oblique member, the first triangle was obtained; and then the erection of the first vertical member of the central bay could be proceeded with, which operation was effected by commencing with the lower length (or section) and finishing with the upper length. At the same time, the cross and diagonal stays in the plane of the corresponding vertical members of the two frames were put in place; and the erection of the first panel was terminated by putting in the lengths (or sections) constituting the upper rib.

After it was ascertained that these parts were in their correct positions, all the joints were riveted up, when the "whale" was run over the upper ribs of the first panel just completed; and it was then possible to begin erecting the second panel exactly in the manner just described, the work being added on, piece by piece, towards the end of the frames constituting half the central bay. The "whale" was then transferred to the counter-bay on the other bank; and the erection of the second half of the central bay was proceeded with in the same manner. As already mentioned, the lever arms of the frames are not equal, and the weight of the counter-bay is not sufficient to balance half the central arch, in addition to which the weight of the latter was increased by that of the "whale" and all the appliances for erec-

tion. Temporary equilibrium was partly obtained by loading the end of the counter bay with a mass of masonry weighing together 280 tons; but, as this mass would not have been sufficient to prevent deflection of the frames, vertical holding-down rods were added, fastened to the end of the counter-bay of each frame at one end, and at the other to a second mass of masonry, weighing about 250 tons, built on the ground surface immediately underneath the end of the counter-bay.

The weight of the masonry built on the counter-bay was so determined as to almost constantly compensate the greater portion of the difference of moments as regards the bearing on the abutment; and the tension of the holding-down rods was intended to complete the difference. The maximum tension which these rods had to support amounted to about 200 tons; and, moreover, this effort was partly sustained by the piers under the ends of the counter-bays, for preventing the wind or unforeseen circumstances from modifying the equilibrium of the structure. The lower ends of the vertical holding-down rods were threaded for receiving nuts, by screwing up which latter it was possible to make the frames turn slightly on the articulated joints at the springings, and consequently facilitate the putting in place of the articulation at the crown.

It therefore sufficed for the operation of keying, after putting in place the pivots at the crown, to screw up the nuts of the vertical holding-down rods at the ends of the counter-bays, thus canting the two half-arches until they met. The keying, however, could only be regarded as actually effected after removal of the masonry masses on these bays; and, inasmuch as the canting could not be recommenced after this operation, it was absolutely necessary to have an exact idea as to the thickness of the packing pieces to be placed under the bearings of the articulation at the crown. These thicknesses had to be determined so as to exactly compensate the compression caused by the thrust due to the weight of the bridge itself, after removal of the lifting gear and finishing the platform, etc., in such a manner that the additional deflection should be exactly that provided for, while taking account, however, of the effect exerted by the temperature. It was therefore important, before the keying was effected, to ascertain exactly the successive forms of the structure at each of the following phases, viz. when contact was obtained without thrust; after suppression of the effect exerted by the holding-down rods before the masonry masses were removed; after the removal of these masses; after erection of the platform and the track, which was not effected at the time of keying; after erection of the connecting bays; and, lastly, after removal of the lifting and all other gear.

Principle of the Bridge.

These forms were determined by a method due to M. Bodin, who enunciated its principle, as follows, in his presidential address to the Société des Ingénieurs Civils de France—a method which permitted of so exactly calculating the adjustment of the parts that, after completion of this difficult operation, and when the bridge was finished, the difference between the estimated and the actual additional deflection was found to be inappreciable, viz. from 1 to 2 mm. only, or not $\frac{3}{32}$ in.

The method with balanced arcs, which was first adopted for the Viaur Bridge—followed by the projected Mirabeau Bridge over the Seine at Paris, the Troitzky Bridge over the Neva at St. Petersburg, etc.—is, at any rate for large spans, more economical than that of ordinary arcs, because the thrust is diminished, and the strain usefully distributed over the longitudinals.

When the span is considerable, and the height above the ground does not permit of putting up a scaffolding, the erection should be effected with overhang; and in this case each piece, or portion of a piece, must have its defined position determined before the next part is put in place. As will readily be conceived, it is absolutely necessary in an important work to make sure that the last piece put in exactly occupies its assigned position; and it is in this manner only that the whole structure will present its predetermined form

when completed. As the system is elastic, its form varies with the addition of each piece and with each displacement of the lifting appliances, so that it is necessary to take these alterations of form into consideration, and calculate them for each phase of the construction.

This calculation can be made very exactly (under the supposition that the system is constituted by articulated bars) by applying the principle of virtual work; but it must be repeated for each one of the points the position of which it is desired to ascertain—a very long operation.

One may proceed to simply set out the work, in order to obtain for each variation of load the complete form of the whole system. In fact, within certain limits, compatible with the form of the system, the alterations of form are proportioned to the loads applied. If, therefore, it be supposed that the loads are n times greater than they are in reality, and reduced or increased in the proportion of n times the increase or diminution caused by the strain, a diagram will be obtained representing the system n times more put out of form, *i.e.* in which the displacements will be n times greater than they are in reality. It is, however, far simpler to set out the work to the scale of $1 : n$, in which case the displacements will be reduced proportionately, and the diagram will show the actual displacements, which can be measured.

Since 1886, when the first project for the Viaur Bridge was got out, this method has been employed by the Société de Construction des Batignolles. The great advantage it possesses is that all the displacements, and consequently all the vertical deflections and horizontal movements, are immediately indicated, without difficulty or trials, so that it is no longer necessary, when endeavouring to ascertain the greatest deflection caused by the loads, to make an hypothesis, or a preliminary diagram, for determining the point where the deflection will take place.

This method, which is, in fact, only a graphical application of the principle of virtual work, was also employed in the erection of the Viaur Bridge, and it indicated the slightest deviation from the correct position of the pieces. It is thus that the keying of the central arch was effected with remarkable correctness, since the difference between the intended and the actual height at the crown is inappreciable.

Calculating the Bridge.

In the calculations for the construction of the bridge, account was taken of the following forces:—

(1.) The permanent loads due to the inherent weight of the structure.—These loads, which are vertical, may be reduced to isolated forces applied at each "knot" (or junction point) of the frames; and it is sufficient, for obtaining this result, to refer the inherent weight of the different parts to their two ends. These forces are, moreover, on account of the symmetry of the structure, arranged symmetrically with respect to the vertical longitudinal axial plane of the bridge.

(2.) The loads due to the passing of the typical train, in accordance with the official regulations.—These forces, which bear upon the upper "knots," or junction points, of the frames, through the platform, and especially through the main transverse girders of the bridge, are vertical, and arranged symmetrically with respect to the vertical longitudinal axial plane.

(3.) The action of the wind.—This action, which is (according to the regulations) to be considered as exerted horizontally, may be reduced to isolated forces applied at the different "knots," or junction points, of the frames. The case of a wind exerting a force of 270 kg. (595 lbs.), without extraneous load, and also one of 170 kg. (374 lbs.) with load, had to be provided for.

The bridge was calculated under the hypothesis of having to carry a moving typical train hauled by two 56-ton engines with 24-ton tenders; but the tests were carried out with 73-ton engines and 26½-ton tenders, and also with 22-ton instead of 16-ton wagons. Notwithstanding this great increase in the load, however, the deflections observed did not exceed what had been provided for in the calcula-

tions; and it was not found that the moving loads caused any transverse vibration in the vertical and oblique members. The dead-weight tests entailed a lowering at the crown articulation of 41 mm. (1·614 in.), while the deflection given by the calculations was 73 mm. (2·874 ins.). Three tests with moving loads were made, of which the most severe was with a train made up of two engines and twenty wagons, representing a total weight of 639 tons. With a speed of 20 km. (12½ mls.) per hour the vertical displacements were 52 mm. (2·047 ins.) at the crown and 76·4 mm. (3 ins.) at the end of one of the counter-bays; and at double that speed, 45·1 mm. (1·775 in.) and 76·9 mm. (3·03 ins.) respectively.

Sundry Particulars.

The work of lifting the parts, putting them together, and riveting up extended over more than three years; but it must be borne in mind that during this period the actual erection had to be interrupted during rain, fog, frost and high winds, which rendered access to the scaffoldings dangerous for the men, who at such times were employed in putting the parts together and riveting them up on the ground surface.

The appliances for inspection and maintenance comprise—a longitudinal track, arranged under the platform and extending the whole length of the bridge, carrying a travelling and steering truck; ladders with round rungs placed inside the lower ribs, which are of box section, and ladders, also with round rungs, fastened to the upper part of the vertical members, while manholes in the upper ribs permit of using these ladders for gaining access to the inside of the vertical members.

The whole structure is of mild steel, except the accessory portions, such as the connecting bays, the platform, and part of the appliances for inspection and maintenance, which are of wrought iron, while the bearing-plates at the articulation are of cast steel.

The metal-work weighs about 3,660 tons, comprising 3,000 tons of mild steel, 550 tons of wrought iron, 43 tons of cast steel, and 36 tons of cast iron, while the total cost of the bridge, including masonry, is put at 2,700,000 frs. (£108,000).

For the photographs from which the accompanying illustrations have been prepared, we are indebted to the courtesy of M. A. Dumas, editor of the *Génie Civil*, which publication has been freely laid under contribution in this notice.

J. WALTER PEARSE, M.Soc.Ing.Civils de France.

The Egyptian Water Problem and Sources of Further Supplies.

ALTHOUGH but recently completed, the beneficial influence of the Aswân dam has already been demonstrated in a most satisfactory manner, and cultivators along the Nile valley are already rejoicing in the removal of restrictions that were necessary in former years for ekeing out the scanty supplies of water then available. But it would be a mistake to suppose that the last word has been said, or that irrigation engineers may now rest upon their laurels.

The object of the present article is to consider briefly the influence that will be exerted by the Aswân reservoir, to take note of its limitations, and to describe in outline the further schemes that have been proposed for placing the water supplies of Egypt upon a sound and wholly satisfactory basis.

The reservoir upstream of the Aswân dam is of very considerable extent. In summer time it extends as far as Ibrim, which is 143 miles above Aswân, but for a length of about 100 miles the impounded water is within the trough of the Nile. A few villages have been submerged, but as measures were taken by the Egyptian Government during 1901 for delimiting the boundaries of the proposed reservoir, and of dealing suitably with all incidental problems, no real inconvenience has been suffered by the former inhabitants.

It has already been stated that the maximum capacity of the reservoir is 1,050 million tons, equal to more than 235,000 million gallons. It will be full by the middle of January in each year, and during May, June, and July water will be discharged for the purpose of augmenting the ordinary summer flow of the river. Taking the necessary period of discharge at the minimum of 75 days, it follows that the additional volume furnished by the impounded water will be approximately 36,000 gallons per second. To this must be added the normal summer discharge of the river. In calculations of this nature, it would manifestly be imprudent to accept averages, for the deficiency of water during one year of poor supply cannot be made good by any mathematical process. Therefore we must only add to the discharge of the reservoirs the quantity to be expected in a poor year, say 50,000 gallons per second, giving a combined discharge of 86,000 gallons per second, thus showing that the effect of the Aswân dam will be to reasonably assure a summer supply approximately equal to the mean summer discharge of the Nile.

The minimum quantity of water required during the summer months for the adequate treatment of the 6,250,000 acres of cultivable land in Lower and Upper Egypt is estimated at 30,000 cub. ft., or, say, 190,000 gallons per second.

Deducting from the 190,000 gallons per second required the 50,000 gallons assumed to be furnished by the river, the balance of 140,000 gallons per second is wanted, towards which, as we have already seen, the reservoir as at present built is only capable of contributing 36,000 gallons per second, leaving a deficiency of 104,000 gallons per second.

Although the original scheme did not provide for a reservoir at Aswân large enough to supply the ultimate needs of Egypt, it did provide for the storage of that quantity of water which was known by Government and other engineers to be urgently necessary for existing demands. Unhappily the loud-tongued clamour of a few antiquarians, in this and other countries, drowned the feebly uttered prayers for water that arose from millions of parched throats in Egypt, and in consequence the capacity of the reservoir was reduced to about two-fifths of the originally intended capacity. Some excuse may be found for those who, worshipping

the temples of Philæ from afar, knew nothing of the dire necessities of Egypt, but it is difficult to justify the fatal weakness of the Government in yielding to agitation militating against the true welfare and prosperity of the nation.

The consequences of reduction in the capacity of the Aswân reservoir will become clear by examination of the following figures. Expressing quantities in cubic feet instead of in gallons, it may be said that the scheme of 1894 provided for the storage of 85 milliard cub. ft. of water, and that according to the modified scheme of 1895 only 35 milliard cub. ft. could be stored. As before mentioned, the capacity of the reservoir is now estimated at a somewhat higher figure, equivalent to about 37 milliard cub. ft.

The provision of each milliard cub. ft. of water is estimated to increase the value of the crops, and therefore the rental value of the land, by £30,000 per annum. Consequently the capitalised value of one milliard cub. ft. of water may be put at £300,000.

The actual cost of the present dam was approximately £2,400,000, and on a similar basis the cost of the dam originally intended may be put at £2,800,000. In addition, we may allow for incidental irrigation and drainage works £1,500,000 in one case, and £3,000,000 in the other.

The following Table presents these figures in the form of a comparative statement.

Table I.—Showing Loss to Egypt by Reduction of Aswân Reservoir.

RESERVOIR AS ORIGINALLY PROJECTED.		
Capitalised value of 85 milliard cub. ft. of water		£25,500,000
RESERVOIR AS BUILT.		
Capitalised value of 35 milliard cub. ft. of water	£10,500,000	
Estimated saving in cost of dam ...	400,000	
Allowance in respect of irrigation and drainage works	1,500,000	
		12,400,000
BALANCE, being loss to Egypt ...		£13,100,000

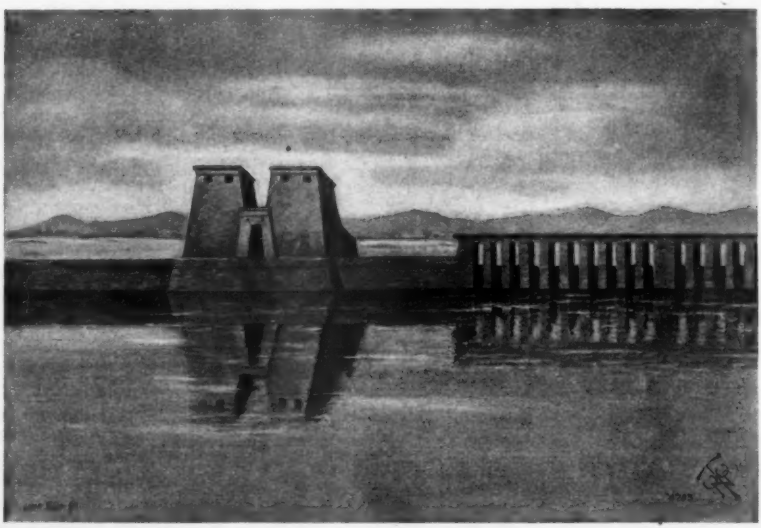


FIG. 1.—A PART OF THE ASWÂN DAM, AS ORIGINALLY DESIGNED BY SIR WILLIAM WILLCOCKS.

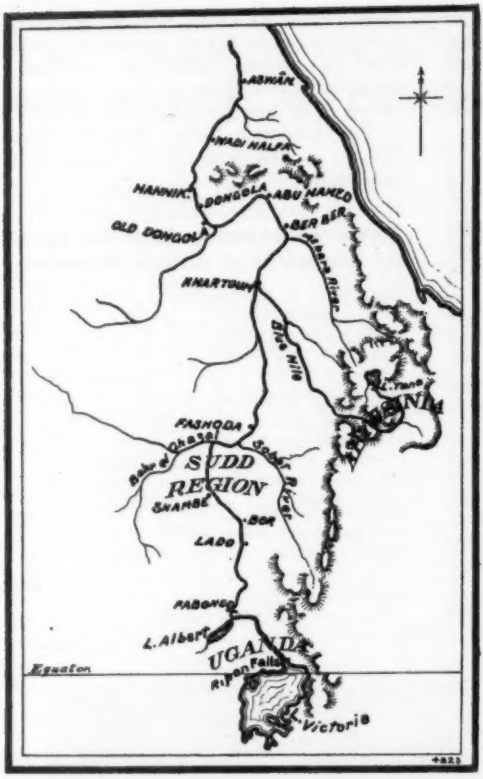


FIG. 2.—MAP OF THE NILE VALLEY FROM THE SOURCES OF THE RIVER TO ASWÂN.

Table II.—Approximate Comparison of Nile Reservoir Schemes.

Author.	Total Storage.	Summer Discharge.	Summer Deficit.
	Mill. Gals.	Gals. per sec.	Gals. per sec.
De la Motte (1880) ...	1,200,000	190,000	—
Willcocks (1894)	534,000	82,000	58,000
Boulé (1895)	800,000	123,000	17,000
Willcocks (1895)	440,000	68,000	72,000
,, (Modified) ...	220,000	34,000	106,000
,, (As Built) ...	235,000	36,000	104,000
Storage necessary for Egypt ...	900,000	140,000	—

Thus it is distinctly shown that the net upshot of the agitation with regard to the temples on Philæ Island is a clear loss to the Egyptian people of more than £13,000,000; or of only £12,500,000 if we take account of the two milliard cub. ft. wh ch the reservoir is now believed to hold in excess of the quantity first estimated.

It has been said that the latest design permits the future extension of the Aswân dam to the height of R.L. 112, giving a reservoir capacity of 70, or perhaps 74, milliard cub. ft. of water. Taking the lower estimate, the ultimate completion of this work will result in an addition to the wealth of Egypt equal to £10,500,000; or £9,700,000 after deducting £800,000 for new masonry and incidental irrigation works. If the higher estimate of capacity be accepted, the net advantage to be gained by raising the dam would be about £10,000,000.

Here it may be remarked that Egypt has lost considerably, in an artistic sense, by the abandonment of the original designs, which provided for a series of dams of imposing elevation, sweeping from island to island in the rocky basin of the Nile, and connected by massive abutment piers and pylons, appropriately reminiscent of early Egypt architecture. The sketch reproduced in Fig. 1 was drawn from the elevation of the design prepared in 1894 by Sir William Willcocks, and will give some idea of the architectural treatment then proposed.

Some day the Aswân reservoir will be brought up to its full capacity, and then the summer supply of water to Egypt will reach a total of 122,000 gallons per second.

Table III.—Approximate Discharge of the Nile and Aswân Reservoir.

	Gals. per sec.
Nile Flood	2,000,000
,, ,, (Very High)	3 000,000
Summer Discharge (Mean) ...	90,000
,, ,, (Poor)	50,000
,, ,, (Minimum) ...	44,000

But some 68,000 gallons per second will still have to be provided to make up the required total of 190,000 gallons per second. The chief data relating to the various reservoir schemes hitherto mentioned are summarised in Table II., and some figures are collected in Table III. as to the supplies afforded by the river alone, and in conjunction with the discharge from the Aswân reservoir.

In order to obtain a true idea of the total quantity of water to be provided in future schemes, it becomes necessary to take waste into account. Adding for this purpose one-third to the necessary storage capacity given in Table II., we have a total of 1,200,000 million gals., or nearly 200 milliard cub. ft.

The important question next arises as to how the further supplies of water now lacking may best be obtained.

In order that the outlines of this great problem may be appreciated, it is necessary to look beyond the boundaries of Egypt proper, and to see what are the conditions affecting the supply of water to the Nile. First, we may briefly trace the course of the river from its head waters to Aswân, as shown in Figs. 2 and 3.

Lake Victoria, the source of the White Nile, is an enormous natural reservoir, measuring some 230 mls. from north to south, and about 220 mls. from east to west, with a coast line of 2,000 mls., and an area of 26,000 sq. mls., that is, more than two and a-half times the cultivable area of Egypt. This inland sea lies in a region where rain falls all the year round,

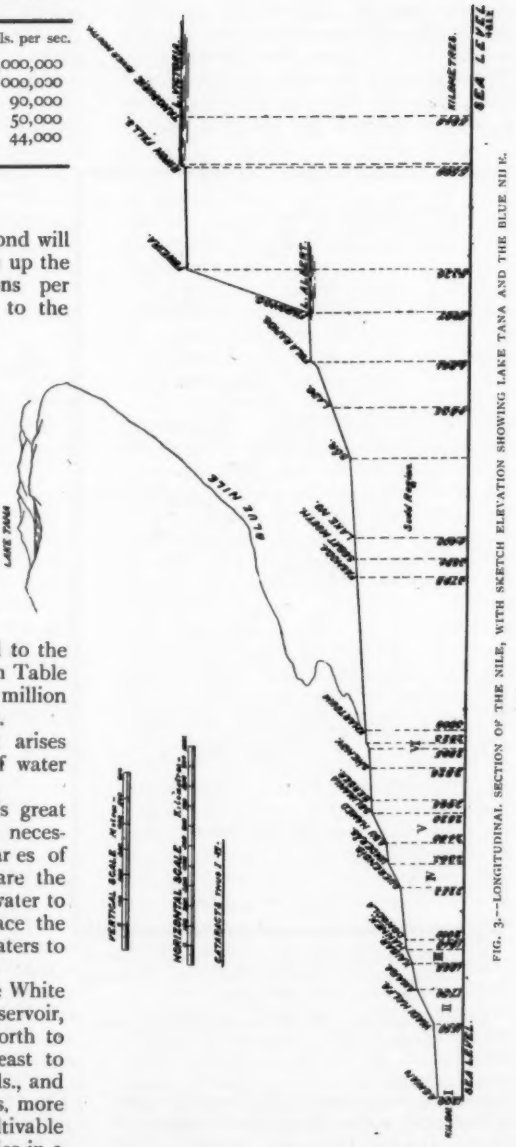


FIG. 3.—LONGITUDINAL SECTION OF THE NILE, WITH SKETCH ELEVATION SHOWING LAKE TANA AND THE BLUE NILE.

and its catchment basin is fully 100,000 sq. mls. in extent. Its capacity is so gigantic that the addition of 5,000,000 million gals. of water would not raise the surface level by more than about 12 ins. The only outlet for water is at the Ripon Falls, where the Nile first appears as a river of between 400 and 500 yds. wide, with an estimated mean discharge of 190,000 gals. per second, and a minimum discharge of about 150,000 gals. per second. This point is extremely suitable for the construction of a regulating dam. For nearly 300 mls. the river races as a mountain torrent along a picturesque course; at the Murchiston Falls it tears wildly through a rocky gorge, and makes a single leap of 120 ft. to the depths below. Thence the river flows steadily on until it enters the narrow neck forming the northern end of Lake Albert. This lake is about 95 mls. long by some 22 mls. broad. It has an area of 1,700 sq. mls. and a catchment basin of 135,000 sq. mls. The estimated discharge of the river on emerging from the lake varies between 125,000 and 250,000 gals. per second.

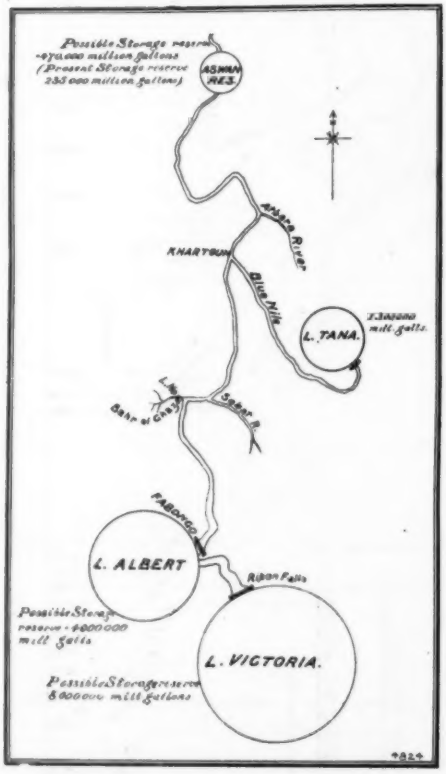


FIG. 4.—DIAGRAM OF THE NILE VALLEY, SHOWING POSSIBLE STORAGE RESERVE IN THE EQUATORIAL AND ABYSSINIAN LAKES AND THE ASWAN RESERVOIR.

The circles representing the lakes and reservoirs are proportionate to the volumes of water in reserve.

Leaving the lake by a wide channel at the north-west corner, the river flows steadily along, forming a series of wide reaches, so that it may be almost said that the lake does not end until Fabongo is reached. Here the high lands approach the river, and this place has been suggested as the site of another dam. Beyond Fabongo the river again grows turbulent, and for a distance of fully a hundred miles it traverses a series of rapids. In the neighbourhood of Lado, the great plain is entered which extends up to and beyond Khartoum. For a distance of 200 mls. below Lado, there is a more or less clearly defined channel, and then the swampy region is reached. Here the waters divide into various spills and channels, although there are two main branches, the Bahr-el-Gebel, and the Bahr-el-Zeraf. It is certain that channels of adequate dimensions could be preserved, even in this level country, if it were not for the masses of floating vegetation known as "sudds." The latter consist largely of papyrus and grasses torn away from the margins of lagoons, which being driven into the narrower channels of the river are compressed into solid masses, from 4 or 5 ft. to 15 ft. thick, and capable of supporting great weights. The effect of these barriers is to divert the waters and spread them over the land in immense volumes, causing the waste by evaporation and absorption of a large

proportion of the summer discharge. The Bahr-el-Gebel passes on, and presently reaches the sluggish and evil smelling waters of the Bahr-el-Ghazal, the confluence resulting in the formation of the permanently submerged area, known as Lake No. Some 60 mls. north, the Bahr-el-Zeraf rejoins the main channel, and 30 miles lower the Sobat river contributes its waters to the Nile. Between Fabongo and the mouth of this river fully 50 per cent. of the minimum discharge of the river is lost by evaporation and other sources of waste. Thenceforward and down to Khartoum, the river preserves a fairly clear waterway in a plain where red sandstone is predominant. At Khartoum, the Bahr-el-Azrak, generally known as the Blue Nile, effects a junction. The head reservoir of this important tributary is Lake Tana, which, situated in the mountains of Abyssinia some 5,650 ft. above sea level, has an area of 1,200 sq. mls. This lake could possibly be made capable of storing a reserve of water large enough to supply the whole of Egypt during the summer. Some 200 mls. lower down, the Atbara river enters the Nile, contributing in flood time large quantities of silt-laden water, so valuable for basin irrigation, and running quite dry in the months of summer.

Beyond the mouth of the Atbara river the Nile flows down to Aswân, and thence to the sea in a clearly-defined channel, receiving no further contributions of water and losing much by evaporation.

From this cursory and purely superficial glance at the main features of a gigantic problem, it becomes clear that more than ample supplies of water are available at the sources of the White Nile and the Blue Nile. But the trouble at present is that too much water is delivered during winter and too little during summer. The obvious remedy for this state of things is to be found in regulation of the great natural reservoirs from which proceed the two main branches of the Nile, so that part of the surplus may be held back during seven months of the year, and discharged during the remaining five months. In addition, it is necessary that improvements should be carried out for the purpose of confining the river to its channel, and so of preventing the tremendous waste now occurring in the swampy regions between Lado and the mouth of the Sobat river.

By building a dam at the Ripon Falls, to slightly raise the level of Lake Victoria, as proposed by Sir William Willcocks, a storage reserve of about 4,000,000 million gals. of water might be held up. A further reserve of a like amount would become available by cutting down the sill at the Ripon Falls, to permit water to be drawn off below the normal level.

Further, by constructing a dam at Fabongo, to raise the level of Lake Albert by about 12 ft., a second reserve of some 4,000,000 million gals. would be created for discharge in summer time.

By the construction of two such dams it would probably be possible to ensure a discharge at Fabongo of 500,000 gals. per second at any season of the year.

Owing to the existing condition of the swampy region between Fabongo and the Sobat, a large proportion of this volume would be lost, but the additional discharge would fully compensate for waste. Dr. Schweinfurth, the well-known African traveller, believes the waste of water in the region named to be fully three times the quantity of water required by Egypt for a whole year, and he contended in 1899, that if the main stream of the Nile were widened and kept full by closing various "spills," the greater part of the water would become available for the supply of Egypt. Sir William Willcocks also advocates the closing of all spills, and the execution of river training works in the sudd region. Such works as these are essential accompaniments of the reservoirs suggested by the lakes, and they would prevent the stagnation that produces the "green water" to which the inhabitants of Cairo and other places have so just an antipathy. While the complete regeneration of the swampy regions would necessarily occupy a period of many years, much advantage is to be expected from the sudd-cutting operations commenced in 1899. Thanks to the energy of the Public Works Department there is now a working channel, 100 ft. wide by 15 ft.

deep, down the Bahr-el-Gebel, and when this has been further widened and deepened the flow of water will be proportionately increased.

Table IV.—Estimated Discharge of the White Nile.

(In million gallons per second.)

Place.	Maximum.	Minimum.	Mean.
Lake Victoria	220,000	150,000	190 000
Lake Albert	250,000	125 000	190,000
Sobat Mouth	375,000	62,500	250,000
Khartoum	940,000	44,000	375,000
Aswân	3,000,000	44,000	625,000

Table IV. gives approximate discharges at different points on the White Nile. It will be seen that the mean discharge at Lake Victoria would be sufficient for the entire supply of Egypt, if it were not for waste by evaporation and other causes. By the establishment of regulating dams at the great lakes, it would become possible to diminish the discharge in winter, and to increase it in summer, thereby affording regulation from month to month, or from season to season, in any given year. The superfluity due to years of abundant rain would be stored up in the two lakes for use during years of little rain, thus balancing the supplies from year to year in a given cycle of years. Assuming waste in the swampy regions to be somewhat reduced by preliminary river improvements, a discharge of 330,000 gals. per second at Lake Albert would assure a supply of about 125,000 gals. per second at Aswân, but the final re-organisation of the river channel should result in so great a saving that 150,000 gals. per second might be anticipated.

More than enough water could be absolutely ensured for Egypt at all times by the construction of the works mentioned.

Another project which has often been discussed of late years, either as an alternative or an addition to the equatorial scheme, is the conversion of Lake Tana into a great storage reservoir. From an engineering standpoint, there is no difficulty whatever in raising the level of that lake. A dam, 10 ft. high, at the rocky outlet would hold up a third of the annual rainfall, thus storing a reserve of fully 1,300,000 million gals. of water. This volume would provide a discharge of about 200,000 gals. per second for 75 days in summer, and after allowing for evaporation would give a supply amply sufficient for the whole of Egypt. The only difficulty in connection with a storage reservoir in Abyssinia is of political origin, for it is not unreasonably thought that it would be unwise to place the water supply of Egypt in the territory of a foreign ruler. For the moment it is only necessary to point out that Lake Tana affords all the physical conditions essential to the realisation of such an enterprise.

Fig. 4 is a diagram of the White and Blue Niles, from their sources to Aswân, the reserve storage of the existing and suggested reservoirs being drawn to a uniform scale for the purpose of ready comparison. It will therefore be understood that the circles represent neither the relative areas nor total capacities of the lakes and of the Aswân reservoir.

There is no reason why reservoirs should not be established both in Abyssinia and in the equatorial district. A reservoir in Abyssinia and irrigation works on the Blue Nile would permit the development of the country traversed by that river, in addition to giving further supplies to Egypt. Such works might be commenced and completed with a minimum expenditure of time and money, and the pressing needs of Egypt would be suitably relieved. Ample time would thus be given for the preparation and execution of a comprehensive scheme for dealing with the White Nile in such manner as to afford an alternative supply of water to Egypt completely under British control; to permit the agricultural development of the Sudan from Khartoum southwards; and to throw open an unrivalled highway for navigation from Cairo to the Equator.

The recent completion of the Nile reservoir works, and the vast improvements effected in the irrigation and drainage systems of Egypt generally, have opened the way for further enterprise.

Perennial irrigation is already being introduced in Upper Egypt, and in due time it will spread along the whole length of the Nile valley. Basin irrigation will probably be employed for renewing the fertility of the waste lands and swamps near the Mediterranean, so that in due time they may share the benefits of perennial irrigation with the rest of the Delta.

The whole question of exact river discharges and additional reservoir works has now been taken up by Sir William Garstin, the capable and energetic Under-Secretary of State for Public Works, and while it is impossible to predict what course may be followed, the people of Egypt may rest assured that the measures ultimately accepted will be wisely conceived, and that when once commenced they will be advanced with energy and determination until brought to a successful issue. His report should mark an epoch in the development of the irrigation of the Nile valley.

At the present day the prospects of Egypt are brighter than they have ever been. Her cultivated area will soon approach that existing in Roman times, but two crops a year will be obtainable where formerly only one was possible. After centuries of misrule and neglect, Egypt has emerged from misery and chaos into prosperity and order, and is now about to enter upon a period of unparalleled progress, when the splendid work accomplished under British control will be eclipsed by still greater triumphs of statesmanship and engineering skill.

W. N. TWELVETREES, M.I.Mech.E.

NOTES ON LOCOMOTIVE AND RAILWAY ENGINEERING.

The writer of the following Notes—the continuation of which as a permanent feature of FEILDEN'S MAGAZINE has been decided upon and duly announced by the Editor—approaches the task of presenting what it is intended shall form a general monthly résumé of the World's Progress in matters relating to locomotive and railway engineering with a great desire to render the matter selected for treatment under this heading of value to all those who, for various reasons, take a special interest in the subjects.

The manufacturer of locomotive engines and railway plant who views the matter mainly from a commercial standpoint, the designer and purchaser (either as one or as separate individuals) whose chief concern lies in the direction of the results obtained from the finished article, as well as the independent observer, represented by a large and increasing number, will all, it is hoped, find items having reference to the particular phase of the subject which most interests them, and the writer will at all times be pleased to hear from readers upon matters of general interest coming within the scope of these columns if they will communicate with him, c/o the Editor.

Classification of Locomotive Types.

THE system which has been adopted in the United States for denoting the various types of locomotives has much to commend it, as it indicates at a glance, by the aid of a few figures, one of the principal characteristics of a locomotive, viz.: the number and disposition of its wheels, thus affording a rapid means of identification. Thus what was previously known as an "American" type engine is now referred to as belonging to type 4–4–0, the figures being counted from the leading end of the locomotive, whilst the term "Atlantic" and the designation 4–4–2, convey precisely the same meaning.

Nothing could be more easy to understand, nor more generally adaptable to varying circumstances than this simple and businesslike method of classification, which it is to be hoped will be brought into general use in this country before very long.

The system is capable of being extended so that it is possible to ascertain, with equal facility, the number and position of the cylinders as well as those of the wheels. This could be effected by introducing additional figures and letters and adopting a mode of expression after the style of a simple formula to indicate the desired meaning. To illustrate this, it may be assumed that a six wheels coupled bogie engine, with outside cylinders, is under discussion. This, according to the new rule in its extended form as suggested, would read $\frac{4\text{–}6\text{–}0,}{0^2}$ an eight wheels coupled goods engine with four cylinders, of the type commonly employed on the London & North Western Railway, would appear thus $\frac{0\text{–}8\text{–}0,}{0^2\text{–}1^2}$ whilst one of the Midland compounds would be described as $\frac{4\text{–}4\text{–}0,}{0^2\text{–}1^1}$ and so on.

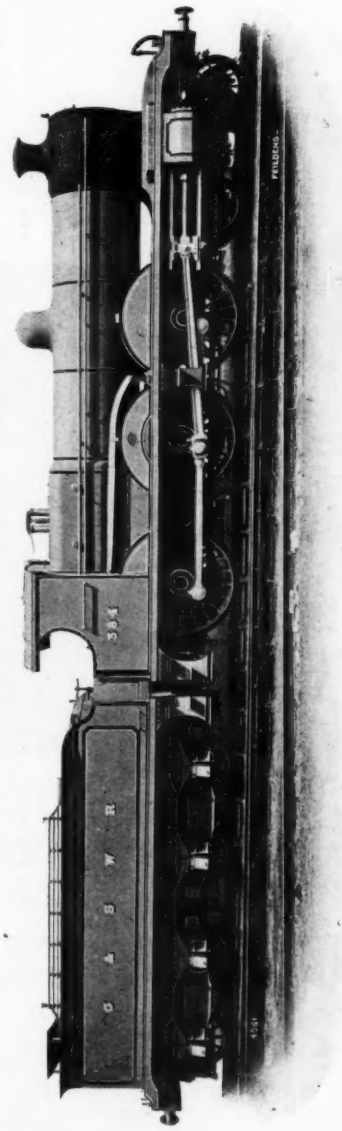
It would hardly be possible to so vary the formula as to shew by its use that, in some cases, the cylinders are separated as in the Glehn and earlier Webb compound locomotives, as this would tend to complicate matters. It does not appear, however, that the additions suggested above would have this effect, at any rate in a sufficient measure to introduce the drawbacks referred to, whilst the use of the few extra figures would enable one to quickly ascertain the number of the cylinders employed and their position with relation to the frames.

Increasing popularity of the 4-6-0 type.

The steady advance in popular favour of the pattern of locomotive known as the six-

coupled bogie, or 4-6-0, type suggests that upon many railways conditions of a kind which favour the adoption of this design of engine are either existing at the present time, or in a fair way of becoming prevalent in the near future. The latest British locomotive Superintendent to introduce the type is Mr. James Manson of the Glasgow and South Western Railway. This gentleman has designed and the North British Locomotive Company have recently completed, several engines of the class illustrated on this page, and these have been put into service on the Glasgow-Carlisle section of the railway in question, for hauling the fast and increasingly heavy express trains forming the through connection between London (St. Pancras) and Glasgow in conjunction with the Midland Company's route. The number of important British railways upon which locomotives of this description have been introduced during recent years is now increased to seven by this latest addition to the list, and it will not be at all surprising if others follow suit before any great length of time has elapsed.

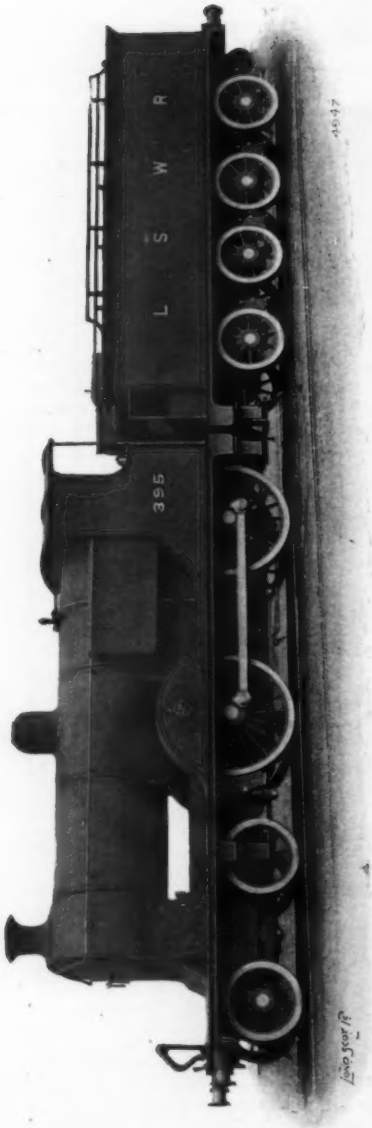
In districts abounding with severe gradients, over which heavy train loads have to be transported at relatively high rates of speed, the 4-6-0 type finds its highest sphere of usefulness, but even in cases wherein the first-named condition is absent in its most pronounced form the six-coupled engine may be used with great advantage. The increased hauling capacity and higher acceleration which is secured by its employment renders it superior to the four wheels coupled type under the special conditions referred to, whilst in the matter of speed, when circumstances are favourable to its development, such as on level stretches and down grades it has been demonstrated on repeated occasions that the six-coupled type is able to approach within measurable distance of the best performances of its four-coupled contemporary, provided of course that the diameter of the wheels is approximately the same in both cases.



GLASGOW AND SOUTH WESTERN SIX-COUPLED BOGIE (4—6—0) EXPRESS PASSENGER LOCOMOTIVE.
Cylinders, diam. 20 ins. by 26 ins. stroke. Working pressure, 180 lbs. per sq. inch.
Coupled wheels, diam. 6 ft. 6 ins. Total heating surface, 1,852 sq. ft.
Total weight of engine and tender (in working order), 117 tons.

The latest Drummond design.

The growing importance of the London and South Western railway which, within the space of a few years has been forced, by dint of enterprise and energetic management into the front rank among British railways, has provided ample scope for development in matters relating to locomotive design as practised by that able and exceedingly up-to-date engineer Mr. Dugald Drummond, whose name will always be inseparably asso-



NO. 395; "MIXED TRAFFIC" ENGINE L. S. W. R.

Cylinders, 19 ins. diam. by 26 ins. stroke.
Coupled wheels, diam. 6 ft. 1 in.
Working pressure, 175 lbs. per sq. inch.
Total heating surface, 1,550 sq. ft.

ciated with the many improvments which he has brought about in locomotive practice in the shape of water tubes for boilers and fireboxes, a novel form of spark arrester and fuel economiser, and other less prominent but highly valuable inventions all tending to increase the operative efficiency of the engines to which they have been applied. The present year has witnessed some remarkable accelerations on previous timings between Waterloo and Salisbury, Exeter, Plymouth, and other Western centres, to which service improvements the Great Western Company, as might be expected, have not been slow to respond. Therefore the need for locomotives possessed of the highest qualities of power and speed, and able to cope with the increased stringency of the conditions which are called into existence by the running of these faster trains is very strongly in evidence at the present moment. West of Salisbury the difficulties of haulage are of a character not easily disposed of. Severe gradients are frequently met with and the general conditions are such as to render the transportation of modern loads anything but an easy task. To meet the extra demands Mr. Drummond has recently brought out a new class of locomotive which although bearing a strong resemblance to his previous designs has many features which differ therefrom. The engine may perhaps be described as a connecting link between the two existing classes of four-coupled passenger engines of the "water-tube" type, viz. the express locomotives with 6-ft. 7-in. wheels and the mixed-traffic series with 5-ft. 7-in. wheels.

No. 395 (the engine illustrated) is also, strictly speaking, a mixed-traffic locomotive, but the diameter of the coupled wheels is such that it will be better suited for the speeds required than the preceding 5-ft. 7-in. class. Mr. Drummond has kindly placed at the writer's disposal some interesting particulars relating to the new engine and the work which it, and others of the same pattern, have been built to perform. From these it appears that the average load to be hauled over maximum gradients of 1 in 70 and 1 in 80 is 200 tons, at a scheduled speed of 53½ miles per hour. This represents work of an exceedingly trying character and calls for the development of great power on the part of the locomotives engaged, therefore the boiler and cylinder capacities have been augmented in the 395 class and the weight on the coupled axles increased. The double bogie tender carries 4,000 gallons of water and 4 tons of coal. Considerable interest attaches to the method employed for balancing the cranks in these engines. By referring to the illustration it will be seen

that the crank webs are prolonged to form balance weights, and it will also be noticed that the wheels are not provided with the usual rim weights, these being unnecessary as all the revolving and part of the reciprocating masses are balanced in the axle and in the planes in which the disturbances are created. Thus the axle is relieved of the destructive stresses caused by the balancing in the wheels. The material used is mild steel throughout, the crank web pins being hollowed, as will be gathered from the illustration. The writer commends this pattern of crank axle, which, it should be added, has been patented by Mr. Drummond, to the serious attention of locomotive engineers on the other side of the Atlantic.

BALANCED CRANK AXLE OF L. AND S.-W. RAILWAY ENGINE NO. 395.

Advent of the de Glehn Compound.

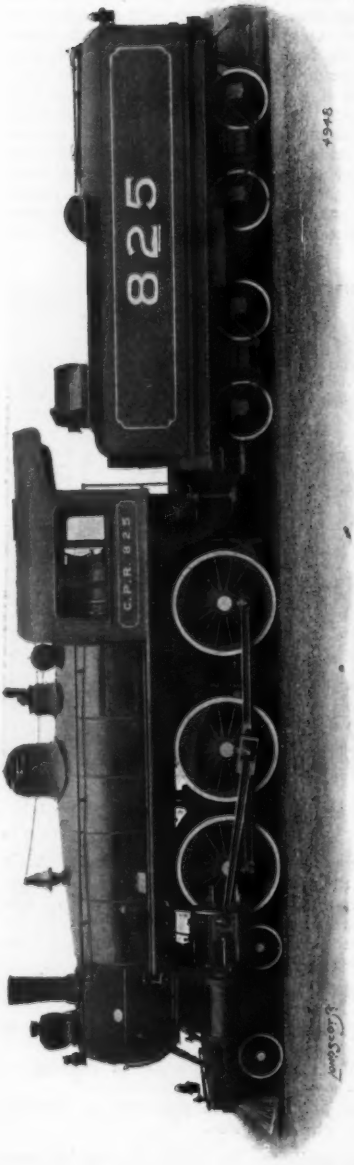
By the time these notes are in print the Great Western Company's de Glehn Compound locomotive will in all probability be completed and ready for despatching to this country. The latest information at the time of writing is to the effect that delivery may be expected early in September, so before October is far advanced, some working results should be obtainable. Meantime we will glance at what is claimed for this design of locomotive, and the groundwork upon which those claims are based, taking for our authority, Mons. de Glehn himself, in a long and highly interesting article contributed by him, to the pages of one of the leading American engineering Journals.*

The Author commences by referring to the marked hostility shown towards his engines at the time of their introduction on the score of complication of parts to which characteristic, as he truly remarks, many engineers are strongly opposed; Mons. de Glehn, on the other hand, records his personal belief that such complication is not only necessary, but indispensable to progress and the development of methods which have proved to be successful. Continuing, he argues with much force that nearly all mechanical advancement has been brought about by and with increased complication, and states that his reason for adopting four cylinders with separate distributions and an intercepting valve was that, with a very definite idea of what it was he wished to attain thereby, and after an experience extending over many years with a number of express engines on all the French main lines, he had come to the conclusion that the type of engine best suited for the realisation of the aims, he had in view was that in which the whole of the above features were incorporated. By dividing the engine and valve gears, he says, you double the number of parts, thereby halving the work which each part has to do, and at the same time you have more room and can thus afford to give larger wearing surfaces; and moreover a better distribution of the strain over the frames themselves is brought about by separating the cylinders and gear. The advantages claimed by Mons. de Glehn for locomotives built upon his system are as follows:—

(1) Maximum rapidity and certainty in starting.
(2) Greatest power for a minimum of weight.
(3) Maximum smoothness of running at high speed.
(4) Maximum adaptability to varying circumstances.

He attributes the facility in starting away

* *American Engineer & Railroad Journal*, 1902, Sept., p. 265.



SIX-COUPLED BOGIE PASSENGER ENGINE, C.P.R.

Cylinders 20 ins. dia. × 26-in. stroke. Coupled wheels dia. 5 ft. 9 ins. Working pressure 180 lbs. per sq. in. Total heating surface 2,421 sq. ft.
Total weight of engine 82 tons 9 cwt.

to the presence of the intercepting valve, as this allows of the exhaust from the high-pressure cylinders being directed from the receiver to the exhaust pipe, so that steam can be introduced simultaneously to both pairs of cylinders; therefore you have what is virtually two engines (four cranks), one high and the other low pressure. By means of the intercepting valve the engine can be used with the high-pressure cylinders alone, or with the low-pressure cylinders alone, in case of accident to either pair, and when starting on a bank it is possible to exert an exceptional pull, by resorting to the expedient of admitting boiler steam to both pairs as before mentioned.

The author asks whether it is possible to figure out the exact value of the advantages claimed so as to see how they count in comparison with the disadvantages of the increased number of parts; and significantly adds that it *would* perhaps be possible under one set of circumstances and for one line or country, but then the comparison might not hold equally good for other and different circumstances. As to the precise value of the advantages set forth, opinions may differ, but it can hardly be said that they are unimportant. It is with this last phase of the subject that we in England are principally concerned just now in view of the forthcoming trials. Every engineer in the country will no doubt follow the working of the French engine with interest. Many opinions have been expressed as to the probable outcome of the impending trials, but all agree that the highest value attaches to the experiments.

A Notable British Triumph.

The North British Locomotive Company are to be heartily congratulated upon the important successes which they have scored in the face of the keenest American and Continental competition. Towards the close of 1902, Messrs. Neil son Reid & Co. (since incorporated wit two other firms under the title referred to), secured the contract for 12 locomotives for the Canadian-Pacific Railway. This number was subsequently increased to 32, and in July last a further order from the same quarter for 20 locomotives of a different pattern found its way to Glasgow. Nor does this represent the extent of the Company's recent operations in respect of contracts for abroad. Besides others, the Natal Government

Railways and the Mexican Central Railway —for both of which large numbers of tank engines are in course of construction—may be cited, whilst among Indian railways the Bengal-Nagpur, East Indian, and Bengal North Western, have each received large consignments of locomotives from these well-known builders. The order for the last-named railway, consisting of 30 locomotives, was completed and the engines delivered fully three months before the stipulated time, a circumstance which drew from the managing director of the railway company concerned a congratulatory letter, expressing the thanks of the Board for the prompt and satisfactory manner in which the work had been carried out.

This calls to mind a certain other Indian locomotive contract of quite recent times, which was secured by Germany, with the promise of delivery months before any British manufacturer would undertake it. The sequel will no doubt be equally fresh in the memories of those who followed the course of events at the time. Those who have forgotten what took place as a result of this contract going to the Continent, may be reminded that at the time when the *last* of the engines should have been delivered in India, the *first* of their number had not even left the builder's works in Germany, for the unsatisfactory reason that the materials which the contractors proposed to put into the engines were rejected again and again by the customer's inspector, on the grounds of inferiority and indifferent workmanship.

Reverting to the subject of the Canadian-Pacific contract, the idea has prevailed in some quarters that locomotive builders in Great Britain would never be able to compete on equal terms with American firms where the pattern of locomotive required was entirely American in design and methods of construction. This supposition has been entirely dispelled by the ease and rapidity with which the engines under notice have been built and the great satisfaction which the C.P.R. authorities have expressed at the result of employing British labour. A glance at the illustration on page 226 will suffice to show that the locomotives are strictly in accordance with American standards, and embody all the fundamental characteristics of transatlantic practice. An opportunity is now presented of seeing whether the admitted superiority of British-built locomotives in respect of economical operation and greater durability is due to the design or the workmanship.

Everyone who has the interests of British trade and commercial supremacy at heart will no doubt find cause for much satisfaction at what has been achieved.

The "Great Central" and London.

The operations of the above Company in the home counties at the present time include constructional works in Middlesex and Buckinghamshire, the contracts being for about 6 miles in the former and 15 miles in the latter country. The main object which the Directors have in view is that of avoiding the Metropolitan Railway, over which the Great Central trains at present have to run for a distance of upwards of 40 miles before reaching the outskirts of London. The existing line between Marylebone and Kingsbury-Neasden will remain as it is and will continue to provide access to the terminus, this length being exclusively Great Central property, but at Neasden the new line commences, and, bearing away in a westerly direction, reaches Northolt at about 10½ miles from London. Here a junction is effected with the Great Western Co.'s new line, also in course of construction, from Acton to High Wycombe. This length will be worked as Great Western & Great Central Joint railway, as will also the 8½ miles of existing Great Western line between High Wycombe and Princes Risborough. At the latter place the Great Central trains will diverge, and, after traversing the 15 miles previously referred to, will strike the Company's existing main line at Grendon Underwood, which is situated about midway between Quainton Road and Calvert.

Through the courtesy of Mr. C. A. Rowlandson, the chief Engineer of the Great Central Railway, the writer was recently afforded an opportunity of inspecting the new Works in the London district, under the able guidance of Mr. A. W. H. Casson, the Resident Engineer, and Mr. James Scott, agent for Messrs. Thos. Oliver & Sons, the contractors who have the Neasden-Northolt section in hand. The particulars obtained on that occasion will be given, together with illustrations, in next month's "Notes."

C. S. LAKE.

The "Houille Blanche" Congress in France.

By M. F. LOPPÉ.

(Member of the Société des Ingénieurs Civils de France.)

(Continued from page 42.)

Avignonnet Power Station.

THIS power station is intended to supply energy according to the industrial needs of the localities situated in the neighbourhood of Vienne, and also to the Mines de la Mure. The station is somewhat similar to that of Drac, but differs from the latter as much from an hydraulic as from an electrical point of view. At Avignonnet an important dam has been erected across the river, and the current is fed directly to the line tension, without intermediate transformers, by alternators which can, according to their method of coupling in star or in triangle, feed either at 15,000 or 26,000 volts. This is the first time that this voltage has been obtained directly from any alternator.

Hydraulic Installation. — The dam is constructed at Avignonnet Gorge, above the Mure. This dam (Fig. 32) has a height of 20 m., not for the retention of water—for the dam has been rapidly silted up by the enormous scouring process of the Drac river, the basin of which has been pretty completely denuded — but for augmenting the available height of the fall.

The width of the dam at the top is 4·75 m., and has a backing of 24 m. at the base. It is constructed of masonry with hydraulic cement.

The sluice (Fig. 33) is fitted with a vane 7 m. by 9 m., and its sill is situated 2·30 m. below the surface of the intake reservoir, and is prolonged, as shown in Fig. 32, by a canal.

The construction of the dam presented great difficulties. The river was diverted by means of a canal of 80 m. long drilled through the solid rock, which emptied the water below the prolonged sluice canal above shown. It was hoped that the dam could be erected on the river bed, but this was found to be impossible, and a foundation of some 8 m. had to be excavated, and piles were driven to a further depth of 3 m. A small road was made to the dam works, and a transporter, with a difference of level of 300 m., was constructed to bring the building materials to the spot, as these were unavailable in the district. For operating the transporter and also the suction pumps, etc., a small power station of 100 h.p. was erected, and worked by means of a small waterfall in the neighbourhood.

At the end of the intake is a canal, 800 m. in length, with an overflow of 65 m. to the river. This canal is of rectangular section 4 m. wide and 2·30 m. high, with a circular arch top and smooth cement sides and bottom. It ends in the charging chamber. From this chamber start two conduits, of 2·30 m. in diameter, supplying the station. The height of the fall varies from 23·50 m. during times of low-water, to 18·50 m. during high-water; and the minimum power on the turbine blades is 4,000 h.p., and can attain 7,500 h.p.

Power Station.—The ultimate composition of the power station will be seven groups of Picard & Pictet turbines of the free derivation type, direct-coupled to Creusot alternators of 1,750 kilowatts. There are now installed three of these groups. The alternators are of the fixed armature revolving field type. As the transport of the parts to the power station was a serious matter, no single part weighs more than 5 tons. In order to conform to this condition the field is composed of two cast-iron wheels,

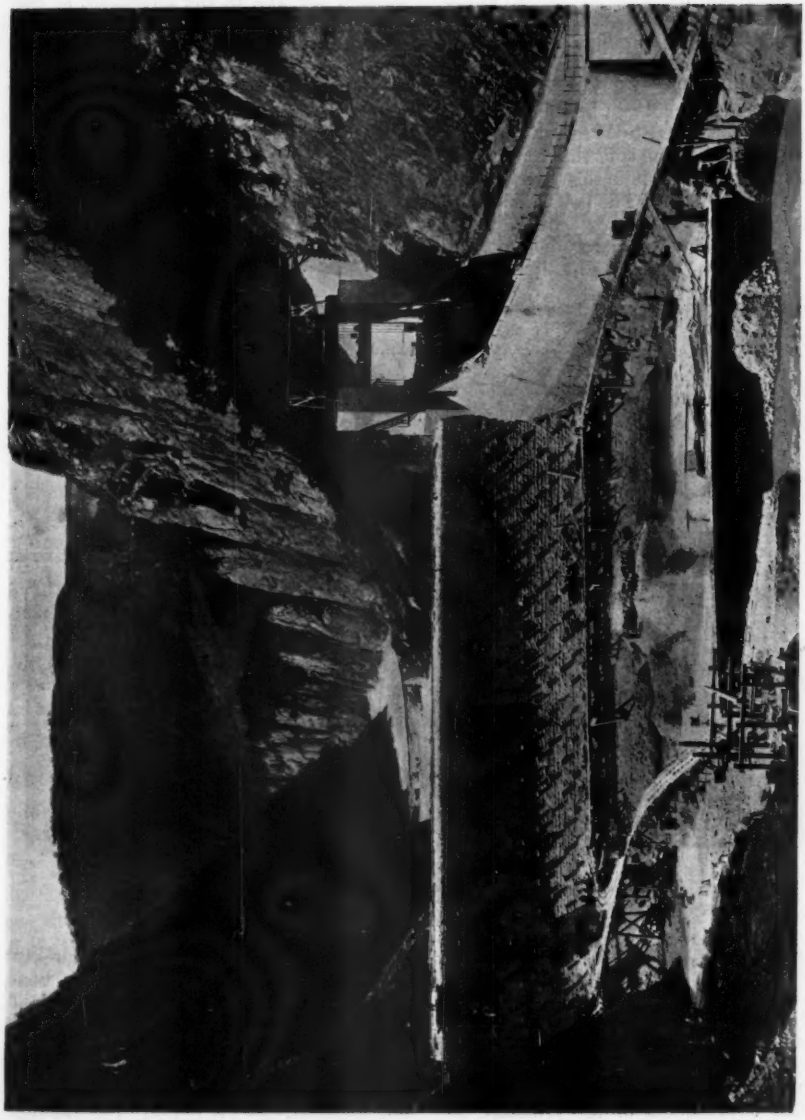


FIG. 32.—AVIGNONNET POWER STATION, SHOWING THE DAM, THE SIDE OUTLET, ETC.

between which is held a crown of cast-steel, carrying the pole-pieces, of which there are 24.

The speed of the group is 250, and the frequency is 50 cycles.

The field-winding is formed of a copper ribbon wound on edge in helical form, the coils being insulated by sheets of specially prepared paper. The coils thus formed are held in position by pole tips fixed to the pole-pieces by bolts. The coils are wound in series for a current of 500 amps. at 100 volts. Six-pole exciters are carried on the ends of the shafts. The fixed armature is made of a cast-iron ring, divided into four parts, each comprising two flanges holding the laminations, and firmly bolted together. The armature is set on two cast-iron caissons, and two jack-screws are supplied which facilitate the horizontal and vertical adjustments of the armature in order to obtain exact centering of the field. The lower part is carried on two rollers mounted on jack-screws, which allow the armature to be turned on itself, around the axis of the alternator, so that the necessary parts may be exposed to make repairs or replacements of the coils. Spaces are allowed between the coils for ventilation and cooling. The armature carries 144 slots, in which lie the 72 coils constituting the three phases of the alternator. These phases are wound in such a manner as to leave between them and the mass large spaces, to avoid short circuits. The three phases may easily be grouped together either in triangle (to obtain a tension of 15,000 volts) or in star (to obtain 26,000 volts tension). The bus-bars are copper bars mounted on porcelain insulators.

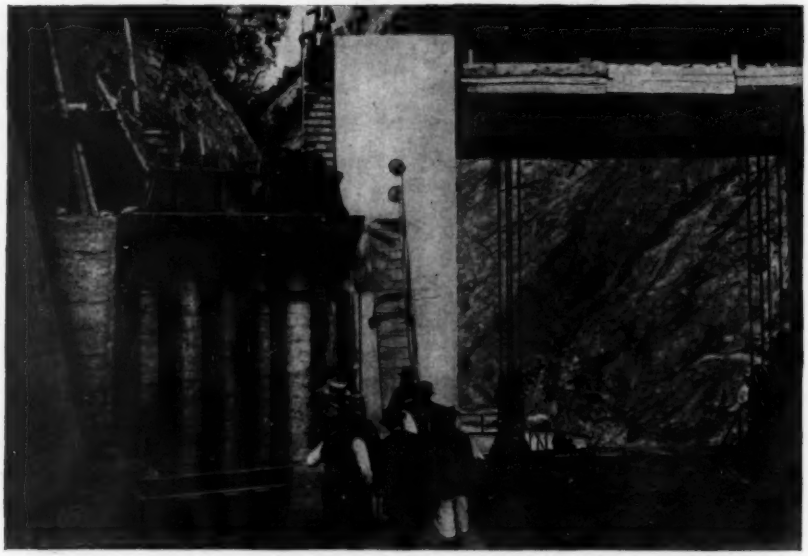


FIG. 33.—AVIGNONNET POWER STATION: OUTLET AND INTAKE VANES.

All the conductors connecting the machines to the switchboard are placed underground in conduits which are of sufficient size to permit easy inspection. The low-tension wiring for the excitation is formed of lead-armoured and insulated cables carried in conduits underground. The high-tension

wiring is made of highly insulated cable carried on three-petticoat insulators carried from the machine to the switchboard and thence to the transmission line.

There are two switchboards in the station, one for the alternators and the other for the line. The front of the switchboard is composed of marble slabs with wooden framing, and carries only the measuring and controlling apparatus, the current for these being supplied by the low-tension wiring.

The high-tension cables and apparatus

FIG. 34.—BIRD'S-EYE VIEW OF THE VOLTA STATION.

are installed on a metal framework, on an extension of the switchboard.

The Machine Switchboard has a length of 14 metres, and includes the machine panels, all similar in every respect. Six metal bars, forming two distinct systems, are disposed on a metal framework behind the switchboard. One of these bus-bar systems is intended to effect the lighting service, and the other the transmission of power. Suitable switching apparatus permits the two systems to be connected together at will.

Each machine panel carries (1) For the excitation: one ammeter, voltmeter, and excitation rheostat, and a field switch. (2) For the armature of the alternator itself is furnished an ammeter, voltmeter, and a three-way switch, one synchronising voltmeter and one synchroniser with six lamps and a two-way switch allowing coupling the armature to any one of the bus-bar systems. The whole of the current output from each set of bus-bars passes through one of the general panels, each of which carries one voltmeter, one indicating wattmeter, and three ammeters. The high-tension side of the machine includes one potential and one current transformer and one switch, allowing the current to be cut off under load, and a set of cut-out fuses allowing the alternator to be coupled to one or another of the sets of bus-bars.

The Feeder Switchback.—This is situated

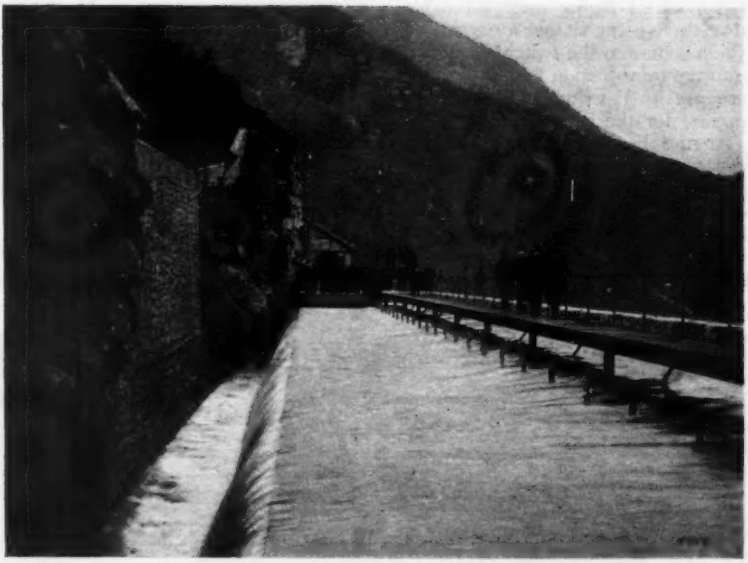


FIG. 35.—VOLTA STATION: THE CHARGING CHAMBER.

on the first floor of the station, and includes six outgoing panels. Two systems of bus-bar connections correspond to the systems on the machine switchboard, and are likewise carried on a framework behind the panels. The service is made by means of the apparatus on this switchboard. Each panel of the outgoing line switchboard includes a switch, one current and one potential transformer, and a set of cut-out fuses, allowing the outgoing line to be connected to one or another of the systems of bus-bar connections. In front of the switchboard are disposed three ammeters, a wattmeter, and a recording meter.

The two upper floors of the station are occupied by lightning arresters. Each outgoing line includes two systems of arresters connected in parallel. In the floor immediately above the outgoing line panel are placed Wurts's lightning arresters, and in the upper story are installed lightning arresters of the horn type. On each ground cable is installed a resistance and cut-out fuse.

One three-phase 50-cycle transformer supplies current for the lighting circuit, and also furnishes power to the motors of the repair shop and to the pumps.

Volta Station.

This station is operated by a fall from the Isere, and is situated two kilometers above that of Moutiers (Savoy). It comprises 19 buildings, covering an area of 7,500 sq. m. (Fig. 34.) It is now an electro-chemical manufactory of Outhenin-Chalandre for electrolysis of all saline chlorides. The intake is installed at St. Marcel, and is built for a maximum charge of 20 cm. per sec. The intake canal has a length of 3,750 m., and is nearly completely underground. Great difficulties were encountered in making this canal watertight, due to the nature of earth, and to subterranean rivers met with. Its section is 12 sq. m., and it is built entirely of masonry. The canal ends in the charging chamber, and in this chamber (Fig. 35) the water passes

through a perforated grating to prevent the passage of leaves and branches of trees, which the Isere carries in large quantity at certain periods.

The overflow of the charging-chamber empties itself into the Isere, and the water in falling forms a fine cascade (Fig. 36).

There is now installed one forced conduit of 0·40 m. in diameter, and 250 m. in length, for the station disposes of only 4,500 out of the total of 13,500 h.-p., which it will ultimately furnish. The fall is of 74 m. height.

In the station are installed nine generator sets of 500 h.p. The turbines are of the free deviation type with horizontal axis, built by Brenier, Neyret & Company, and are coupled by elas ic couplings to the dynamos. No regulator is provided.

Six of the generators are of Creusot construction, D.C. machines, and the remaining three are Alioth generators, alternating current machines.

Chedde Power Station.

The intake of this station, on the Arve, is the same as that used for the Servoz power station of the P. L. M. Fayet-Chamonix railway, which will be briefly described later. The water, after passing through the Servoz power station, or directly from the intake, is led in a gallery, partly underground and partly open to the air, to the charging chamber *C* (Fig. 37), whence two forced conduits of 1·40 m. diameter, which run along the road *D*, from Geneva to Chamonix, and then along the Arve (*E*), ending at the power station. The height of the fall is 140 m., and the volume can attain 10 cub. m. In this electro-chemical factory are installed 12 generator sets, with turbines running at 230 revolutions per minute. The turbines are of the Brenier-Neyret (Grenoble) build, and are free derivation, with horizontal axle.

The D. C. dynamos are of 560 kilowatt, with eight poles, four being of the

FIG. 36.—VOLTA STATION: CONDUIT AND DISCHARGE FLOW.

Creusot construction, and four of the Société Alsacienne. The remaining four are made by the Alioth Society.

The intake of this station being held in common with that of the Servoz station of the P.L.M. railroad, the cost-price per h.p. installed is as low as 13 frs. on the turbine blades, and 22 frs. at the terminals of the dynamo. This is probably the lowest price that could be made.

Fayet-Chamonix Railway Line.

This line has a length of 19 km., and is 1-m. gauge. It unites Fayet station (Fig. 38), at the end of St. Gervais les Bains, to Chamonix, and the difference in level between these points is 457 m. (Chamonix is about 1,050 m. above sea-level.) There are two steep grades, one of 9 per cent. for a length of 2,155 m., and the other of 8 per cent. for 1,386 m. The other grades do not exceed 2 per cent. This line, which is the prolongation of the normal gauge line of the P.L.M. which ends at Fayet, is thus worked in a special manner. In fact, the passengers being brought to Fayet by the ordinary trains of the P.L.M. railway, it was not considered advisable to use single cars on the electric line, for fear of causing delays to passengers, in case more than one car-load wished to continue their journey. The trains are not, however, drawn by locomotives, but by motor-cars. The ordinary train on the electric line comprises four passenger cars and one baggage van. The whole weighs 90 tons, and provides accommodation for 128 passengers. The current is brought to the train by means of a third rail placed along the track at a distance of 1·085 m. from its axis. The top of the third rail (formed, like the track, of Vignole rail of 12 m. length, and weighing 34·4 kg. to the m.), is 0·23 m. above the level of the track rails.

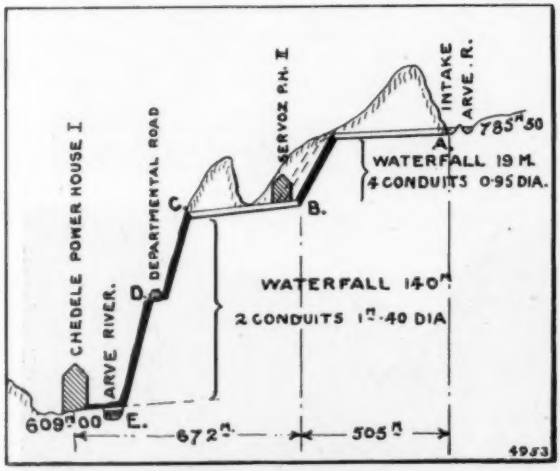


FIG. 37.—CHEDDE STATION: DETAILS OF FALL.

This conductor rail is supported by a sleeper fixed to the cross-ties, and insulated therefrom by means of paraffined wooden insulators. The rails are bonded at the ends by means of two copper bonds of 2·4 cm. diameter, soldered at each extremity to a cast-iron stud. Good contact is made from the ends of the bonds by means of copper sheets pressed each side of the rail with bolts. At level crossings and at certain points in stations, the conductor rail is interrupted over a maximum length of 5 m., and the circuit is formed by a copper cable placed in a wooden conduit. In stations, in order to avoid danger to passengers and servants, the rail forming the conductor is protected with wooden planks.

The lighting circuit is taken from the track serving as a current return; the bonding is effected on the track in the same manner as on the third rail conductor, but there is but one copper bond of 2·4 cm. between two consecutive ends of rails.

At a distance of every 500 m. the two tracks are united by a copper cable.

Power Stations.

Although the service on the line might have been accomplished by one station, it was thought advisable to ensure a constant service by installing one more. The interruption of service was apparently feared by reason of the inconstant nature of the river supplying power to the station. Both stations are used for the service. The first station is situated at Servoz, and the negative pole is connected to the track, and the positive pole to the third rail in immediate neighbourhood of the station. From the Chavants station eight cables are led. Four of these cables are connected to the negative pole of the machines and the track at the 9th km. The other four cables are connected to the positive pole and the third rail conductor at the 11th km. Between km. 11 and the extremity of the line at Chamonix, the third rail conductor is doubled by a feeder cable.

Hydraulic Installation of the Stations.

Servoz.—As above stated the intake is the same as for the Chedde station. This intake is situated at a point in the Arve where the river is divided by a rock, and the two arms are both supplied with a dam. The intake is situated in the rock itself, in the middle of the stream, and is protected by grating with three vanes. The decantation chamber is underground, with a length of 230 m., and the water attains a speed at the end of this chamber of 0·47 m. per sec., and the maximum intake is 8 cub. m. The decantation chamber communicates, by an underground gallery of 250 m. in length, with the charging chamber of the station of the railway installation (Fig. 37). From the intake a discharge gallery is carried away direct to the Chedde power station, without passing through the Servoz station. From the charging chamber, sheet-steel

FIG. 38.—FAYET STATION: FAYET-CHAMONIX RAILWAY.

conduits are led away (sheet steel of 0·95 m. diameter), to supply the station (Fig. 39). The height of the fall is 38 m.

Chavants Station.—The dam in this case is three m. high, and is in the form of an arc with the convexity upstream. It is solidly abutted to the rock at either side of the river. The intake is formed by an opening, the bottom of which is 2·40 m. above the bottom of the river, and it is furnished with grating and vanes. The intake chamber has a regulating apparatus, and communicated by a gallery

FIG. 39.—SERVOZ STATION: THE CONDUITS.

of the length of 1,093 m., with the decantation-chamber of 123 m. in length, and thence is led by a second gallery of 1,055 m. to the charging-chamber.

From the charging-chamber two conduits of sheet steel (0·80 m.d.) with a length of 450 m. end in the station.

The height of the fall is 94 m., and the maximum flow of water is 12 c.m. per second.

Machinery Installed in Stations.

The two stations have installations pretty much alike. The stations have two floors. The lower, or ground floor, includes the admission and discharge apparatus. The first floor is a machine room. Each machine room includes four six-pole D.C. dynamos (Fig. 40) of 200-kilowatt output, 550 volts, operated by centripetal turbines with horizontal axis, built by Brenier & Neyret. Two four-pole dynamos, of 40-kilowatts each (Fig. 41), operated by centrifugal turbine with horizontal axis, are used as separate exciters for the main generating sets. The service is assured by three of the 200-kilowatt main dynamos and one of the two 40-kilowatt exciters. The remaining 200 kilowatt machine is held in reserve. The turbine of 40-kilowatts operating the exciter is supplied with speed regulator with servo-motor. The turbines operating the 200-kilowatt machines are not supplied with regulators. By a special shaping of the vanes in these turbines, their no-load speed is limited. At full-load they give 450 revolutions per minute, and at no-load they run at 580 only. The dynamos provided with constant excitation from the 40-kilowatt sets are also provided with a compounding effect which acts in such a way that, in spite of the diminution of the speed corresponding to the increase in load, the voltage at the points of junction of the feeder with the third rail conductor is always 550 volts.

Rolling Stock. (Fig. 38.)

The carriages have two axles, each equipped with an Alioth motor series, wound for 53 h.-p., 4 poles. In order to avoid all chance of slipping, the two motors are connected permanently in parallel.

Each carriage is furnished with a controller with five steps, three of which have resistances in the circuit corresponding to the various starting phases. The fourth step corresponds to a speed of 30 k.m.

per hour on level. The fifth step corresponds to the series winding in order to obtain a speed on level of 40 km. per hour. The controller of each car may be hand-operated by the motor-man. In addition, when the carriages form a train, the controller of each car may be operated by the motor-man at the head of the train. Each motor-car includes a servo-motor, with compressed air, operating the controller; and on the head car is installed a main servo-motor, or master-controller, for the simultaneous control of all compressed-air controllers.

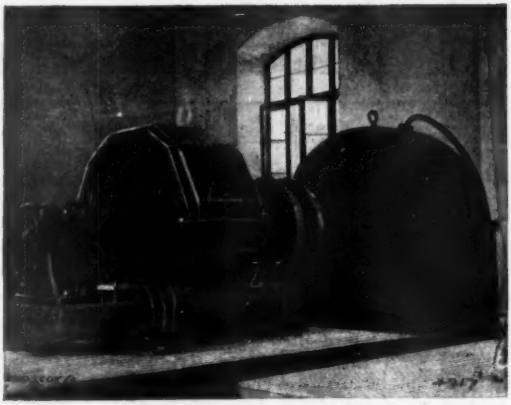


FIG. 40.—FAYET-CHAMONIX RAILWAY: ONE OF THE MAIN GENERATING SETS.

The servo-motor of each carriage is connected to the compressed-air reservoir of the car by two pipes, one serving for the forward direction, and the other for the backward or reversing motion. For either direction the motor-man may vary the pressure in either of the pipes, and thus cause all the controllers to take any desired position. Each carriage is supplied with an ordinary brake, with four shoes, acting on the wheels; and also a rack-brake, acting on the central rail, on the grades of 8 or 9 per cent. The two brakes may be hand-operated when the carriage is running alone, either by the motor-man or by means of the compressed-air apparatus.

The lighting of each carriage is assured by incandescent lamps of 110 volts, placed five in series. To insure a constant voltage there is installed an Alioth regulator, by means of which three resistances can be brought into circuit, according to the intensity of the voltage.

After a general meeting at Chamonix, in which were voted several motions or propositions relating to the technical and administrative questions, the Congress was dissolved. One party of members, at the head of which was the President of the Congress, Mr. Pinat, took part in an excursion to Switzerland to visit the Simplon Tunnel works, the transmission of power at high voltage, direct current, at St. Maurice-Lausanne, the station at Vouvry, with a fall of 950 m. in height (the highest in the world), and the hydraulic installations of the City of Geneva.

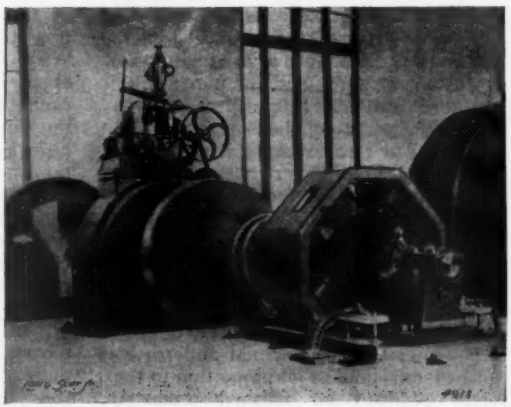


FIG. 41.—FAYET-CHAMONIX RAILWAY: EXCITER SET.

TOPICS OF THE MONTH.

German Syndicates and British Industries.

IN these days when the tariff problem is so prominently before the public, the influence of German commercial syndicates upon British industry deserves serious consideration, and the organisations known in Germany as "cartels" should not be overlooked. A syndicate proper regulates both production and sale, doing away with all direct intercourse between producer and buyer, and controls the conditions of sale for an entire branch of manufacture through one central office. A "cartel" is an association which, while permitting individual production by the firms concerned, limits freedom of action. The organisation of both classes of syndicate has been rendered possible by modern facilities of production and locomotion, and their primary object was simply the regulation of supply and demand. Within recent years this purpose has been made subservient to that of augmenting prices in the home market, and of reducing them in foreign markets. During the recent commercial boom in Germany, the syndicates were able to run prices up to a very high point, as customers were glad to purchase at almost any rates. The prospect of large profits, suggested by the success of this policy, called into existence a number of large manufacturing establishments for which there was scarcely room, and certainly no real need. At the same time the syndicates were in a position to force their customers to make contracts extending over long periods, when prices were at their highest. Therefore, when the boom was on the wane, customers were obliged to pay prices for raw material and partly-finished goods out of all proportion to the prices obtained for finished products. This position was not at all satisfactory for small manufacturers of various kinds of goods, but the syndicates managed to protect themselves, while the strength of their position was increased by the practice of granting private export bounties, and of reducing stocks on the home market by sales abroad at ridiculously low rates, the latter practice being rendered possible by the fact that the prices charged in the home market were high enough to secure an average profit on the gross turnover. The same policy is still in evidence, with the result that so far as Germany is concerned, the foreign market is supplied at the expense of the home market.

The theory held by the syndicates is that foreign customers are necessary for the purpose of providing an average reduction in the cost of production, and that such foreign customers can only be secured at the world's market rate. We have no fault to find with this theory, which is entertained and acted upon by our own manufacturers with a considerable amount of success. It is a striking fact that British manufacturers are able to sell their goods in foreign markets at current rates, in spite of hostile duties and the additional cost of transport. With German manufacturers the case appears to be different. Their products cannot be sold to the desired extent at the world's market rate. German sellers have been so anxious to do business that they have felt constrained to undersell the rest of the world. This operation has been effected by means of the artificial prices exacted from customers in Germany, and the result is that outside market rates have been reduced. Instances of sales at absolutely absurd prices are contained in various trade reports, one of the most glaring being that of the German Wire Tack Manufacturers' Syndicate, mentioned in a consular report issued last month by

the Foreign Office. In six months' trading this syndicate made a profit of £60,000 on the home market, and lost no less than £42,950 by foreign sales. There is no sense in this, even from the Teutonic standpoint, and it would pay very much better to do a smaller trade at legitimate rates on the home market.

But the trouble is that Germany has built and equipped too many factories, and is now obliged to find an outlet for goods at any price. This applies to almost every branch of industry, for Germany has become a veritable land of syndicates; in fact, in 1902 there were no fewer than 450 of such associations. The legitimate object of protective duties has been diverted from that of benefiting the people of the protected country. Customs duties are made the lever for getting an extra turn on the screw. Home prices are raised by the all-powerful syndicates to the highest possible point, but are always just a little below those necessary for foreign goods, which, beyond the cost of production, have to include customs duty, freight, and other incidental charges. We are more particularly concerned with the effect of these developments on British export trade, but it may be interesting to note, in passing, their influence in Germany itself.

Small manufacturers who buy partly-finished products have to pay exorbitant rates, and in many cases it is actually cheaper to re-import German material from Holland, or even to transfer factories to that country, because raw material can be obtained more cheaply there. So extravagant have the abuses of the syndicates become that a commission has been appointed by the German Government to inquire into their working, this step having been hastened by representations made by the Russian Minister of Finance.

From these statements it will be seen that the United States is not the only country suffering from the arbitrary and unjustifiable action of powerful industrial combinations, in whose hands the well-meaning regulations of a government are turned into instruments of oppression. We have no right to complain if duties are imposed by foreign nations for the purpose of helping feeble industries to stand up against British competition. We may even flatter ourselves that the world fears our competition, for there is no country that dare admit our goods to its markets without the exaction of toll; and this in spite of the fact that we are in every case at a disadvantage owing to the cost of freight, and further, that we are without the artificial aids afforded to exporters in other countries. To take an example, the competition of British coal is a considerable source of worry to German coal-owners. The coal syndicate offers exceptional terms in districts where competition is keen, with the avowed object of ousting British coal from the market. Consequently our export of coal to Germany, which amounted to 550,000 tons in 1900, fell to 200,000 tons in 1901, and to 190,000 tons in 1902. But the fact remains that, in spite of enormous odds, we are still able to hold our own to a considerable extent.

Again, we have no right to complain if German syndicates think proper to punish customers of their own nationality, so that German products may be sold at half-price in British markets. The remedy is entirely in our own hands. All we have to do is to fix an import duty so that the prevailing prices of German goods may be increased to a fair market value. Then, if it pleased them, German manufacturers would still be able to sell at about half the cost price, but our own industries would no longer suffer disadvantage. Under such circumstances our Teutonic friends might find it impossible to sell their wares in this country to any considerable extent, and the syndicates would therefore be able to devote their energies to the reduction of prices in their own country. Hence the adoption of customs duty on our part would benefit two nations.

It may be urged that the economically immoral abuses of protective duties by German Syndicates constitute an argument against Protection. If so, it may be said on the other hand that the abuse of our free markets by the same syndicates

provides an argument of equal value against the condition which is wrongly called Free Trade. We do not propose to commence a discussion of fiscal policy generally, but the remark may be made that in a country such as our own, the prosperity of the people depends mainly upon the prosperity of industries that are the true source of national wealth. It may be pleasant for individuals to buy cheap German goods. For every sovereign so saved, however, two or more sovereigns are lost by the country at large, and the British working-man is the heaviest sufferer in the end.

Modern Views of Matter.

In the Romanes lecture recently delivered at Oxford by Sir Oliver Lodge, he gives an interesting outline of the electron theory, and concludes with some interesting speculations as to its outcome. Twenty years ago electricity was regarded as something far more unknown and mysterious than ordinary matter. To-day all this is changed; and, although the man in the street still regards everything electrical as clothed in mystery, while matter, which he can see and handle, appears to him to have no mystery at all, it would be difficult to find a physicist who does not recognise that we really know more about electricity than we do about matter. The trend of physical research at the present moment is in the direction of finding electrical explanations of all material phenomena.

Many years ago Maxwell pointed out that the results of Faraday's electrolytic researches pointed towards an atomic theory of electricity; and later, in a famous lecture at the Royal Institution, this was further emphasised by von Helmholtz. What Faraday showed was, that every atom of matter can have associated with it a certain definite quantity of electricity called the ionic charge, and while multiples of such a charge may be attached to an atom of matter, no atom is ever found carrying fractional portions of this ionic charge. As Sir Oliver Lodge points out, this smallest known unit of electric charge was first called an electron by Dr. Johnstone Stoney. After pointing out that the electrification of an atom is effected by the attachment of electrons to it or their detachment from it, he dwells on the exceeding minuteness of electrons compared to the size of the atom to which they are attached.

Lord Kelvin has shown that if a drop of water could be magnified up to the size of the earth, the atoms of which it is composed would have sizes somewhere between those of cricket balls and of small shot.

There is good reason to suppose that the comparatively small atom of hydrogen contains some 700 to 1,000 electrons, and Sir Oliver observes, that some 16,000 would be contained in an atom of sodium, about 100,000 in an atom of barium, and 160,000 in an atom of radium. He points out that there is very strong, though not absolutely conclusive, evidence that the size of electrons compared to that of the atoms is such that if an electron were represented by a sphere an inch in diameter, an atom of matter would be represented by a sphere a mile-and-a-half in diameter.

Sir Oliver points out that the reason why this evidence is not absolutely conclusive, is that, whereas the mass and the charge of an electron are both known, we are not quite certain that the mass is entirely due to the charge. It is possible, he observes, although he considers it very unlikely, that the electron may contain a material nucleus in addition to its charge. Put into other words, this means simply that in addition to the electro-magnetic mass, which is to a considerable extent understood, there may be some other kind of mass which is not understood at all.

The view here set forth by Sir Oliver, that the mass of all atoms is entirely electro-magnetic, receives strong confirmation from some recent mathematical investigations by Prof. Abraham of Göttingen, into the dynamics of electrons, combined with some experimental results recently obtained by Kaufmann.

W. Wien showed, some years ago, that in

an electro-magnetic system of mechanics, the masses, in place of being invariable, vary in a manner depending on the velocities of the electrons, when these approach the velocity of light. Kaufmann in his experiments on the electric and magnetic deflection of Becquerel rays, has demonstrated the existence of such a variation in the mass of the electrons

Abraham's fundamental equations are obtained without other assumptions than that the velocities of the electrons do not approach that of light, and that they undergo no sudden changes. He applies his formulæ to obtain numerical results in the case of spherical electrons, which can be compared with Kaufmann's experimental figures. He finds a very close agreement in the case of kathode rays, and of the slowest Becquerel rays, on the assumption that the masses of the spherical electrons are entirely electro-magnetic.

The result of assuming the existence of other masses in addition to the electro-magnetic ones would be to render this agreement less close. Assuming an atom of hydrogen to consist of 700 electrons, then, in the case of the atom being uncharged, 350 of these would be positive and 350 negative.

The comments of a contemporary on this portion of the lecture show the existence of a misconception which it is as well to clear up. It is argued that these electrons would exactly neutralize one another, so that a hydrogen atom constituted in this way would have no mass. It must be borne in mind that there is no such thing as negative mass. A system consisting of a negative electron and a positive electron will have a mass equal to the sum of the masses of the two electrons, provided that they are not allowed to come in contact with each other. If this happens they will cease to exist, and therefore the mass will disappear.

Sir Oliver appears to incline to the theory suggested by Larmor, that the stability of the system of electrons composing an atom is dynamic, the electrons being in orbital motion round one another, making each atom a kind of miniature solar system. This is a most attractive conception, and either orbital or spinning motions of the electrons appear to be essential to the explanation of magnetic phenomena. Voigt has shewn that a resisted spin of the electrons is capable of explaining both paramagnetic and diamagnetic phenomena.

T. H. Jeans, however, has shown that in the case of dynamical stability due to orbital motion, an infinite number of vibrations about a state of steady motion would be possible, with the necessary result that the spectrum of a gas would be continuous, instead of consisting of bright lines. He has also shown that if the assumption is made that all electrons, whether similar or dissimilar, repel each other at very small distances, then a stable structure may be found by an arrangement of concentric shells of electrons, alternately positive and negative, the outermost layer being in all cases negative, to agree with observed phenomena.

Sir Oliver calls attention to the demonstration by Larmor and others that light and other electric radiations are due, and only due, to the accelerated motion of electrons. This radiation involves loss of energy, and indicates that atoms, though their lives may be long compared to the life of a stellar system, are not absolutely permanent. This is experimentally confirmed by the phenomena of radio-activity. Professor Rutherford has quite recently shown that the main factor in radio-activity consists in the throwing off with great violence of actual atoms of matter, not merely negative electrons, as in the case of the kathode rays. Rutherford succeeded in demonstrating that the emanations have an atomic weight of 100 to 200 times less than that of the radio-active substance itself, and which he expected might turn out to be either hydrogen or helium. This expectation has been confirmed by the results of some experiments by Professors Ramsay and Soddy, described in a letter to *Nature* of July 16th. These two observers have succeeded in obtaining very complete spectroscopic evidence of the presence of helium after the elimination of hydrogen from the emanations.

This looks very much like an actual demonstration of that transmutation of matter which was the dream of the alchemists in the middle ages.

Sir Oliver makes an interesting suggestion as to the possible cause of such disintegration. As pointed out above, electro-magnetic mass is a function of the speed, but in such a way that it is practically constant until the velocity of light is very nearly attained; when this is reached, the mass suddenly becomes infinite, which means that some kind of catastrophe must occur, and disintegration of the atom, partial or complete, does not seem to be an unlikely consequence.

This result might be arrived at simply by the acceleration resulting from the radiation, the effect of which is similar to that of a resisting medium.

Of the whole mass of atoms, very few are in this unstable state at any one time.

Sir Oliver observes that a radium atom, like a nebula, is not hot, but it too has a great store of potential energy, immense in proportion to its mass, for it is controlled by electrical not gravitational forces; and just as the falling together of the solar materials generates heat, so that a shrinkage of a few yards per century can account for all its tremendous emission, so it has been calculated that the collapsing of the electrical constituents of a radium atom by so little as one per cent. of their distance apart, could supply the whole of the energy of the observed radiation—large though that is—for something like thirty thousand years.

Sir Oliver's very interesting lecture concludes with some further astronomical analogies and speculative suggestions.

REVIEW.

Continuous-Current Dynamos and Motors and their Control.—By W. R. Kelsey, B. Sc., A.I.E.E., F.Ph.S. London: The Technical Publishing Co., Ltd. 5*s.* net.

The first five chapters of this book originally appeared in the columns of the *Practical Engineer*, from the pen of a writer whose name is not mentioned, and the remaining chapters have been written by Mr. Kelsey. Chapter I. is occupied with various units of measurement, and Chapter II., commencing with a consideration of the field of force surrounding a conductor, leads up to the production of electrical "pressure" by induction and the principles underlying the action of the dynamo. These principles are further discussed in the next three chapters, which serve to make clear the general characteristics of such machines. The author then takes up the task of continuing the subject by showing how the principles previously enunciated are applied in the design and construction of continuous-current dynamos and motors. Various forms of armature winding are described, from the simple two-circuit single-ring winding in bi-polar field, to the four-circuit quadruple drum-winding in multipolar field. Some notes on the mechanical construction of armatures are also given, which, although of little service to the designer, are useful as conveying general information on constructive details. After a somewhat brief discussion of field magnets and exciting coils, other details, such as shafts, bearings, brushes and brush-gear, are described. The theory of commutation is then taken up, and receives the attention due to its importance. In Chapter XIII. the author commences the consideration of motors and starting devices, giving special attention to motors and gear suitable for electrical traction, a course which is justified by the growing importance of electricity in tramway systems. In the same chapter, flux-speed-torque curves for motors excited by different methods are discussed, and after brief notice of motor-generators and constant-current dynamos, the work concludes with two chapters on efficiency and testing. Taken as a whole, Mr. Kelsey's work may be commended to those requiring information upon continuous-current machines, as a clearly-written and well-arranged guide. It is well illustrated, and we are pleased to notice that the author has made frequent use of curves, a method of expressing results that is of material assistance in all departments of electrical work.

The Bursting of Emery Wheels.*

SEVERAL years ago the writer was consulted regarding some points of a case in litigation occasioned by the bursting of an emery wheel and the resulting death of a workman. The question to be decided was whether the wheel was unsafe at the speed recommended by the makers, or whether the accident was due to the carelessness of the operator.

As it was just then an off year for experiments on fly-wheels there seemed to be no good reason why the same medicine could not be tried on emery wheels. The apparatus already described in a former paper,* with some slight alterations, was adapted to the new requirements, and in the spring of 1902 fifteen wheels of various makes were tested to destruction.

For the actual details of the work, credit is due to Messrs. Chandler & Krueger, of the class of 1902 Case School of Applied Science. Most manufacturers of this class of wheels test them for their own information, but the results are not generally given to the public; the writer knows of no published data on this subject. At the Norton Emery Wheel Works, all wheels are tested before leaving the shop at a speed double that allowed in regular service, and occasionally wheels are burst to determine the actual factor of safety.

Emery-wheel accidents are not uncommon, but can usually be traced to the carelessness of the operator. One common cause of failure is allowing a small piece of work to slip or roll between the wheel and the rest. The writer was once present at an occasion of this kind, and although he, fortunately, was not in the plane of rotation he has never forgotten his sensations.

The wheels selected for the experiments were all of the same size, being 16 ins. in diameter by 1 in. thick, and having a hole $1\frac{1}{4}$ in. in diameter.

* A former paper by Prof. Benjamin appeared in Vol. VII., pp. 198-205, of FEILDEN'S MAGAZINE. The present paper was read before the American Society of Mechanical Engineers, and forms part of Vol. XXIV. of the *Transactions* of that Society.

FIG. 1.

The object of the experiments being to determine the bursting speed of such wheels as are actually on the market, emery wheels were obtained through various outside parties without indicating to the agents or manufacturers the use to be made of them.

In this way wheels of six different makes were obtained, the label on each wheel showing usually the maker's name, the grade number or letter, the quality of emery and the speed recommended for use. As shown in the table of results, the working speed varied in the different wheels from 1,150 to 1,400 revolutions per minute, the average being about 1,200 revolutions per minute. For a diameter of 16 ins. this corresponds to a peripheral velocity of about 5,000 ft. per minute.

The table also shows that the fineness of the emery varied from ten to sixty, the average being about thirty.

The wheels were held between two collars, each $6\frac{1}{8}$ ins. in diameter and concaved, so as to bear only on a ring $\frac{3}{4}$ in. wide at the outer circumference.

The method of testing, and the apparatus used were precisely similar to those described in No. 3. Vol. vii. of FEILDEN'S MAGAZINE, and in Vol. xxiii. of the *Transactions* of this Society, to which reference is here made for illustrations of the apparatus.

The table shows the results of the experiments in detail, and needs but little explanation. The illustrations, Figs. 1 to 7, show the characteristic fractures and the appearance of various wheels after bursting.

Wheels numbered 1, 2, and 3, were of one make, and show a remarkable uniformity in strength (Fig. 1).

Nos. 4, 5, 8, and 9, were all made by one firm; the two latter wheels were of finer grain than the others, and show a correspondingly greater strength (Figs. 2 and 4).

Nos. 6 and 7 contained a layer of brass-wire netting imbedded in the emery, and were about one-third stronger than the average of the ordinary wheels (Fig. 3).

The wheels numbered 10 and 11 were the weakest among those tested, but have an apparent factor of safety of between 5 and 6 (Fig. 5).

TABLE.

No. of Test.	Grade Mark.	No. of Emery.	Working Speed.		Bursting Speed.		Speed Ratio.	Factor of Safety.	Remarks.
			Revs. per Minute.	Feet per Minute.	Revs. per Minute.	Feet per Minute.			
1	4·5	20	1,200	5,030	3,100	13.000	2 58	6·67	
2	4·5	20	1,200	5,030	3,200	13,400	2·67	7·14	
3	4 5	20	1,200	5.030	3,350	14,020	2·79	7·73	
4	Q	30	1,250	5,2 :0	3,750	15.700	3·00	9·00	
5	Q	30	1,250	5,230	2,750	11,500	2·20	4·84	
6	H	30	1,400	5.870	4,550	19,050	3·25	10·56	Wire Netting.
7	H	30	1,400	5,870	4,600	19,200	3·28	10·76	
8	O	36	1,250	5,230	4,100	17,200	3·28	10·76	
9	O	36	1,250	5,230	4,125	17,250	3·30	10·89	
10	2·5	60	1,150	4,830	2,750	11,500	2·39	5·71	
11	2·5	60	1,150	4,830	2,900	12,100	2·52	6·35	
12	M. H.	14	1,200	5,030	3,100	12,970	2·58	6·66	
13	.	24	1,200	5,030	3,800	15,900	3·17	10·00	
14	H	10–12	1,200	5,030	4,100	17,200.	3·42	11·70	Vulcanized Rubber.
15	H	10–12	1,200	5,030	4,350	18,200	3·62	13·10	

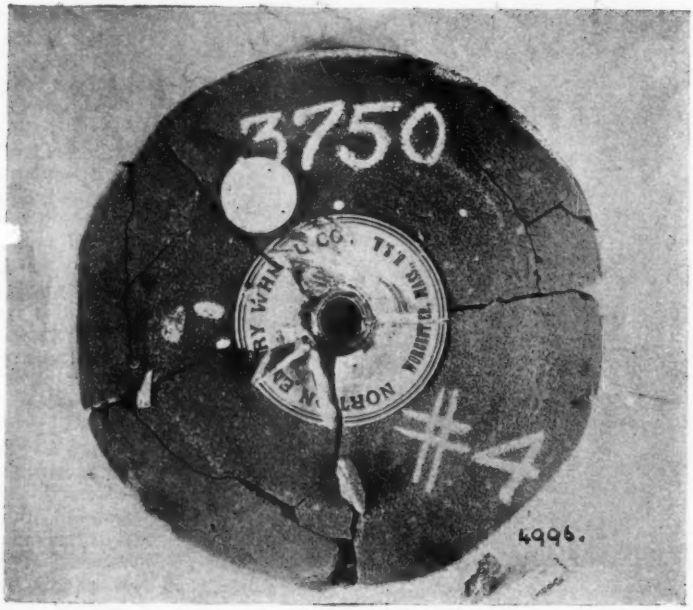


FIG. 2.

Nos. 12 and 13, of still another make, burst at about the average speed (Fig. 6).

Wheels Nos. 14 and 15 were so-called vulcanized wheels, containing rubber in the bond, and intended for particularly severe service. These showed, as was expected, rather more than the average strength (Fig. 7).

An examination of the last two columns in the table shows that the wheels burst at speeds varying from two-and-a-quarter to three-and-three-quarters the working speed, and accordingly had factors of safety, varying from 5 to 13.

It is then apparent

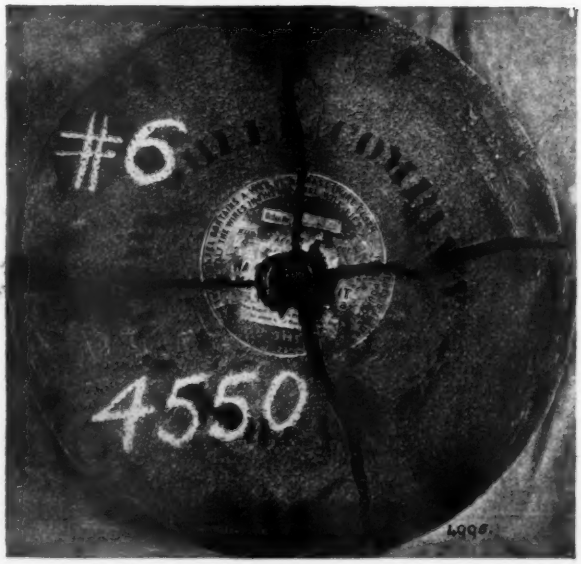


FIG. 3.

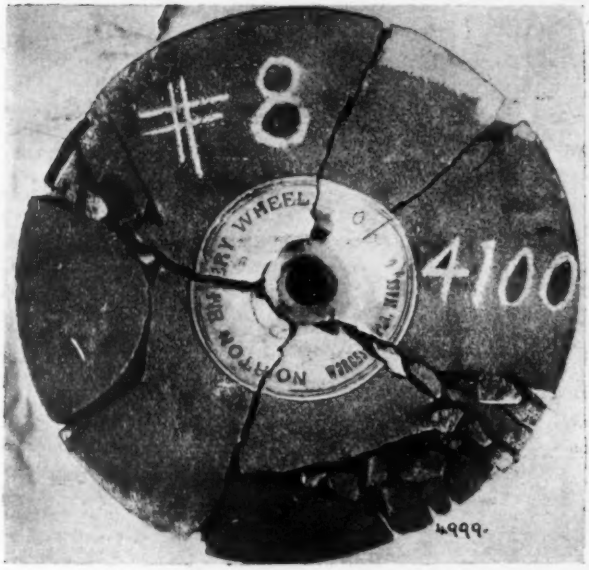


FIG. 4.

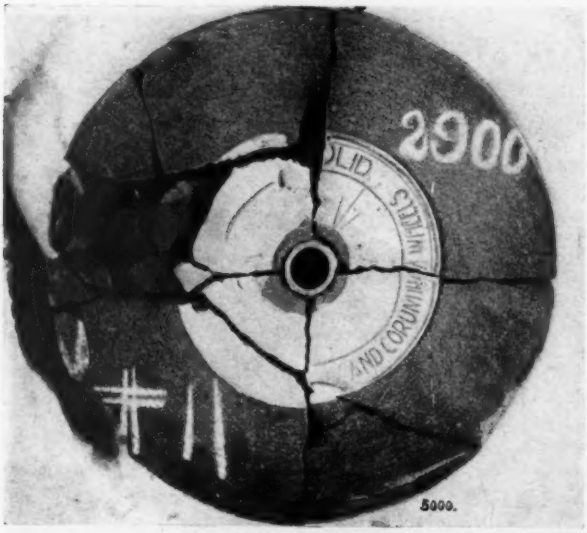


FIG 5.

that any of these wheels were safe at the speed recommended, and would not have burst under ordinary conditions. At the same time, considering the violent nature of the service and the shocks to which they are exposed, it would seem that the factor of safety for emery wheels should be large. In comparison with those generally used in machines, a factor of 8 or 10 would seem small enough.

It may also be said that such a variation in strength between wheels of the same make and grade as, for instance, that between Nos. 4 and 5 indicates a lack of uniformity which causes distrust.

The fractures were in the main radial, as may be seen from the cuts, the wheel splitting in three, four or five sectors as might chance.

It may be assumed that these radial cracks started from the rim, where the velocity and stress were greatest, but it is a fact worthy of notice that in nearly every instance the cracks radiated from points where the lead bushing projected into the body of the wheel.

C. H. BENJAMIN,
M.A.S.Mech.E.

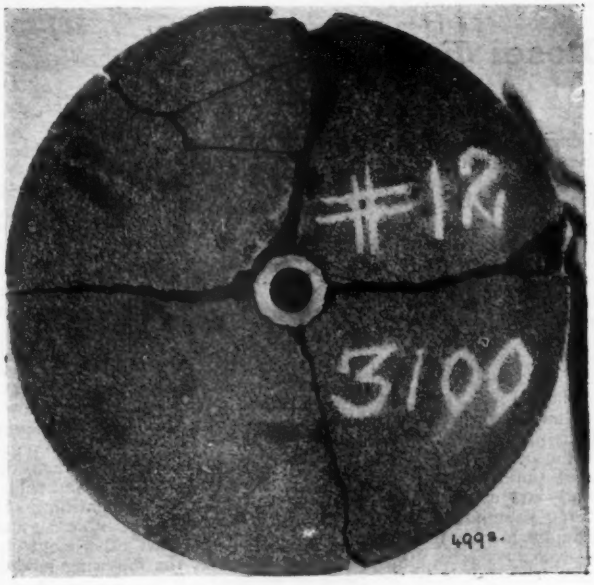


FIG. 6.

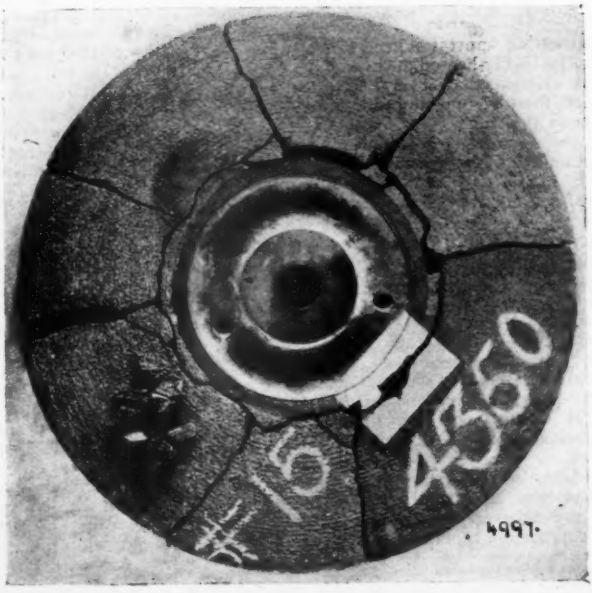


FIG. 7.

The Diesel Engine.*

THE Diesel engine is an internal combustion engine, intended to work with gaseous, liquid, or solid fuel. At present developed as an oil engine, it works on the four-stroke cycle and is vertical.

Herr Rudolph Diesel, after careful analytical and experimental study of the present forms of heat engine, and after comparing their cycles of operation with the ideal Carnot cycle, concluded that all existing engines were worked on defective principles, and that no radical improvement in their efficiencies could result until the principles of working were altered.

Rationally following up this destructive criticism, he then proceeded to construct a new process for the utilisation of the heat of a combustible in the internal combustion engine, and finally laid down the following conditions as being essential for the utilisation of the maximum amount of heat in the combustible :—

(1) The highest temperature in the cycle of operations must be produced by isothermal and adiabatic compression of the air only, previous to the introduction of the combustible.

(2) The combustible must be gradually introduced into the highly-heated air in such a fine state of division that it is instantaneously burned, thereby supplying the heat necessary to keep the gases at a constant temperature during the period of combustion equal to that attained during the compression of the air.

(3) The use of a large and definite excess of air proportioned to the heat value of the fuel is necessary, so that the temperature of combustion may be kept at the highest temperature of compression, and so determined that the engine may be worked and lubricated without using a water-jacket.

The complete cycle for such an engine would be :—

(1) Isothermal and adiabatic compression to the maximum pressure and temperature.

(2) Isothermal combustion and, finally, adiabatic expansion to atmospheric pressure and temperature.

This is, of course, the Carnot cycle, and Herr Diesel has here laid down the conditions which are necessary to obtain the most perfect combustion compatible with maximum utilisation of the heat in a possible engine.

These original analyses, proposals and experimental work will be found in detail in Herr Diesel's book entitled "A Rational Heat Motor."†

In the original attempts to carry out this cycle of operations in 1893, the high pressures and high ratios of expansion used required a three-cylinder engine. One designed to burn dust-coal was constructed and experimented with. The experience then obtained brought to light many points of practical importance, and indicated how far materials and methods of construction at present allow the ideal to be carried into practice.

The next step was to consider where and how far the ideal cycle could be modified, without unduly diminishing the actual and the theoretically possible thermal efficiencies. After two years' experiment and discussion of results, the following modifications were adopted :—

(1) The attempt to obtain an isothermal step in the compression period was abandoned, adiabatic compression alone being employed. This allows the high temperature necessary at the end of the compression to be obtained without using an excessively high pressure ; but it results in more heat being thrown away in the exhaust.

(2) The expansion was not continued to atmospheric pressure, in order to reduce the bulk, weight, and cost of the cylinder per horse-power.

Having solved the initial difficulties of making an engine work successfully on the proposed cycle, it became necessary to make a powerful engine without using an immoderately large cylinder. The solution was obtained by carrying on the combustion at the pressure of 30 to 40 atmospheres (430 to 570 lbs. per sq. in.) instead of isothermally ; the result was of course an increase in temperature of such character that the water-jacket became necessary, and this, in the final form of the engine, was adopted.

The actual Diesel engine has the following cycle of operations :—

First stroke takes in air alone at atmospheric pressure and temperature.

Second stroke compresses this air to a high pressure (35 atmospheres = 500 lbs.

* Abstract of a paper read at the Leeds Meeting of the Institution of Mechanical Engineers.

† English Translation by the late Bryan Donkin. E. & F. Spon.

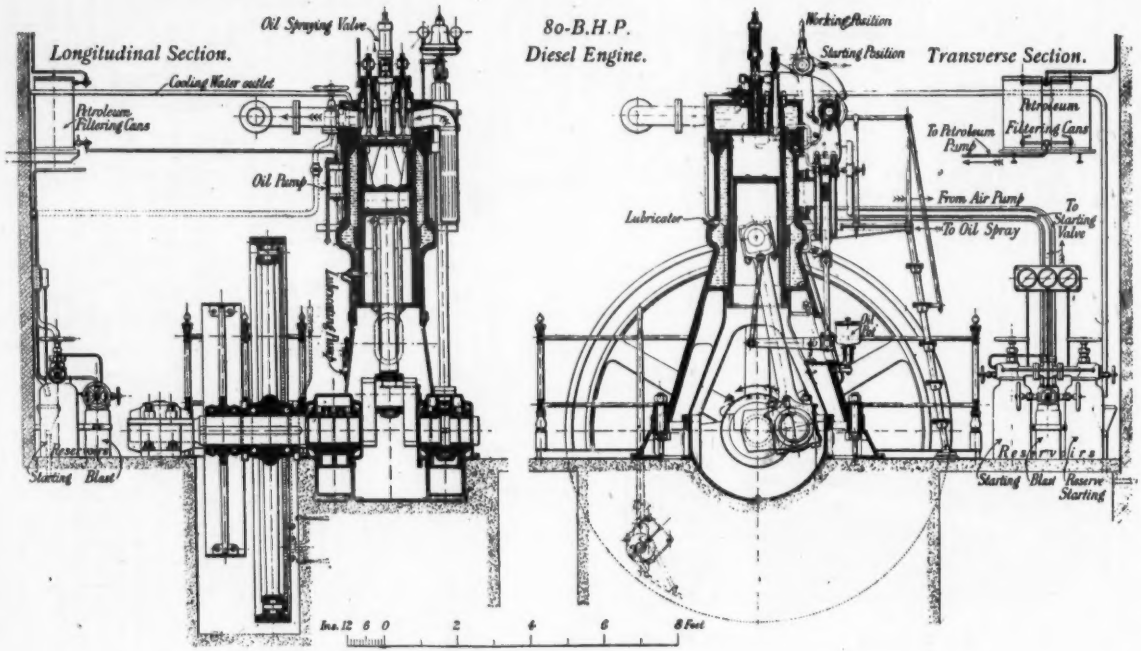


FIG. 1.—80-B.H.P. DIESEL ENGINE.

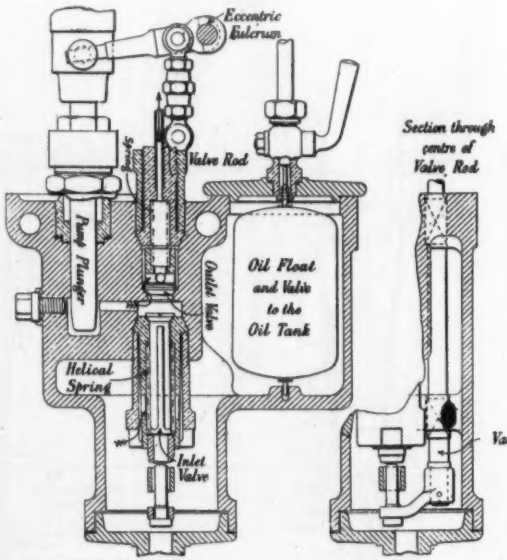


FIG. 2.—OIL-FUEL PUMP

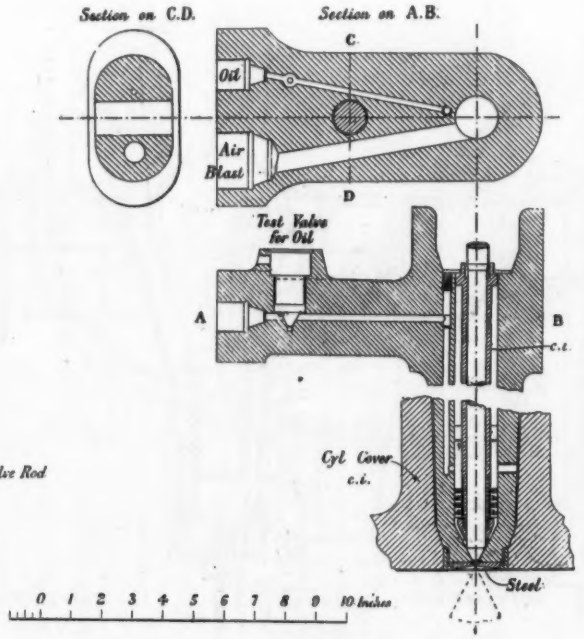


FIG. 3.—OIL-SPRAYING VALVE.

per sq. in.) and to a temperature of about 1,000 degs. Fahr. This compression is neither isothermal nor adiabatic, since the operations are conducted in a water-jacketed conducting cylinder.

Third stroke is the working stroke, during the first part of which the combustion of the fuel is carried on at constant pressure for a period which is determined by the amount of oil to be sprayed in, which quantity is controlled by the governor. The second part of this stroke is approximately an adiabatic expansion.

Fourth stroke exhausts the gases.

80-B.H.P. Engine.

This size of engine is made by the Vereinigte Machinenfabrik, Augsburg, and Carels Frères, Ghent. At Fig. 1 is illustrated a longitudinal section and a transverse section of the engine, with standard arrangements of piping for petroleum, lubricating oil, cooling water, air-blast, starting air and exhaust; in fact, all the engine connections except the water-cooling tanks, when such are used.

The engine is of the vertical type, with a strong cast-iron *A* frame, the upper part of which forms the outer wall of the water-jacket; into this upper part is fitted a cylinder of specially close-grained cast-iron. The cylinder cover is deep and hollow, being thoroughly water-jacketed. In the transverse section will be seen two valves; the central one is the oil-sprayer, the other is the starting-valve, which may be made to act as the suction-valve for the air-pump. In the longitudinal section three valves are seen in the cover: in the centre is the oil-sprayer (for detail see Fig. 3), on the right is the air-inlet, and on the left is the exhaust-valve. The oil-spraying valve opens upwards or outwards, and the others open downwards or inwards; all three are spring closed, the air and exhaust-valves being kept closed by pressure inside the cylinder. All valves are opened by the action of the bent rocking-levers seen upon the right in the transverse section; the movements of the levers are determined by the cams placed upon the horizontal cam-shaft. The cam-shaft is driven at half the speed of the crank-shaft, by means of the bevel gearing and the vertical shaft seen on the right in the longitudinal section.

The governor is of the loaded centrifugal type, and is placed at the top of the vertical shaft; its action is explained in connection with the oil-pump, Fig. 2.

The piston is of the usual open trunk type, directly connected to a connecting-rod of the marine type. There are seven piston-rings of the Ramsbottom type—six near the top and one much lower, in order that it may pass the lubricating channels.

The crank-shaft is solid, and has three bearings fitted with ring lubricators. The fly-wheel is built in halves, and on the inner edge of the rim is a toothed ring into which work two ratchet-pawls, actuated by a rocking-lever; this device is for bringing the engine into the starting position, that is, with the crank just beyond its top dead-centre.

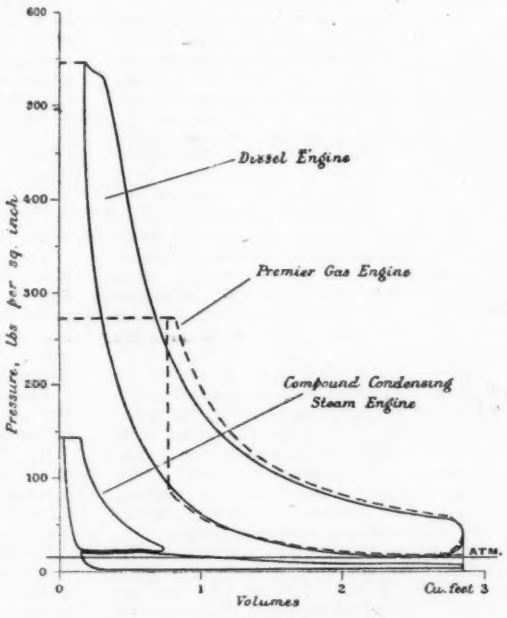


FIG. 4.

On the left of the longitudinal section, Fig. 1, is the petroleum pump. This pump is connected by a pipe to the petroleum-filtering tanks, and by a pipe of small bore

to the oil-spraying valve. The plunger of this pump is driven by a crank-pin placed in a disc at the end of the cam-shaft, and so has a constant stroke.

On the right of the transverse section, Fig. 1, is the air-pump; its cylinder is thoroughly water-jacketed, and the plunger is driven by connecting-rod, rocking-levers, and connecting-links from the small end of the connecting-rod. This pump takes its air from the engine cylinder just before the end of the compression stroke, still further compresses this air, and delivers it to the air-blast reservoir. In the earlier designs the pump took its air direct from the atmosphere, and was then much more bulky and less efficient.

The air-blast reservoir is the smaller one on the right of the cross section, and is connected to the oil-spraying valve for injecting the petroleum into the cylinder against the high pressure of 35 atmospheres already existing there; for this purpose the pump maintains a steady pressure in the reservoir of 5 to 15 atmospheres higher, that is, from 40 to 55 atmospheres. It is also connected by an overflow valve to the air-starting reservoir, this valve allowing air to pass from the blast to the starting reservoir when the pressure in the former exceeds a predetermined value. There may be a similar overflow valve connecting the engine cylinder to the starting reservoir, in order that the maximum compression pressure may be controlled.

The cylinder lubrication is forced, by means of the pumps seen on the left of the engine in the longitudinal section, the lubricant entering at five or six points in a horizontal plane, below which one piston-ring passes. The crank is lubricated by the ring and oil ways seen in the longitudinal section. The lubricant is forced to the small end of the rod inside the piston.

The water-jacket is very complete, as the sections show, entirely enveloping the engine cylinder walls and end and also the air-pump. The water enters at the bottom of the engine jacket and passes upwards through this jacket and the air-pump jacket, from the top to the cylinder cover, the outlet being close to the exhaust pipe.

The oil-spraying or pulverising valve is illustrated in detail in Fig. 3. The horizontal section shows the petroleum and air-blast passages to the central valve, and the vertical section shows the body of cast-iron, with the petroleum passage and overflow or test valve, the central needle valve with its guiding sheath and at the base the pulverising device, consisting of a set of four metal rings of special form perforated by small holes and separated by four metal bands; the terminating nose piece has narrow channels cut in it, through which the pulverised oil passes to the expanding orifice, and is sprayed into the cylinder when the needle valve is raised. It will be seen that the petroleum pump delivers petroleum to the nozzle by the narrow passage, and that the nozzle is in direct communication with the air-blast reservoir, the pressure in which is kept steadily about 150 lbs. higher than the maximum pressure of compression. This device works well.

The petroleum pump is shown in Fig. 2. The plunger has a constant stroke, being driven from the end of the valve cam-shaft. Passing through the head of the plunger is a lever working upon an eccentric fulcrum; to this lever is attached the valve-rod, which opens the inlet-valve against the action of a spring. The fulcrum of the rocking lever is eccentric to the shaft upon which it is placed, and this shaft is caused to rotate by the action of the governor, thus altering the stroke of the valve-rod, and through it the opening of the inlet-valve, and controlling the amount of oil passing to the pump chamber to be forced past the outlet-valve to the injecting-valve.

There is a controlling device shown, by which the inlet-valve can be held open, thus allowing the plunger to pump back the oil to the pump reservoir tank instead of passing it on to the engine by way of the outlet-valve. The tappet of this device encircles the valve-rod foot-tappet.

The normal running of this engine is on the ordinary four-stroke cycle, with the following distinguishing characteristics:—

(1) Very high compression of the air, to about 500 lbs. per square inch, and a temperature of 1,000 degs. Fahr., so that the fuel burns at once on being injected, needing no igniting device whatever.

(2) The gradual injection of the fuel into this volume of highly heated air, by means of a blast of air at about 100 to 150 lbs. per square inch higher pressure than is already in the cylinder.

(3) The gradual and complete combustion of the fuel as distinguished from the explosive combustion of the ordinary type of gas or oil-engine.

Until April 1902 all published trials of Diesel engines were either of Continental or American origin. So the author, upon learning that the Harrogate Corporation were putting in a 35-b.h.p. Diesel engine, at once applied to the Borough Engineer, to be allowed to test it; this permission was most courteously granted, and the author proceeded on April 9, 1902, to test the

engine on the brake. The oil used was a crude petroleum from Texas, having a specific gravity of 0·922 and a calorific value of 19,150 B.Th.U. per lb. The result of the test, less than half a pound of this oil per b.h.p.-hour, was very gratifying to the author, after usually getting nearly twice this consumption from the ordinary type of oil engine.

160-B.H.P. Engine.

On March 7, 1903, by the kindness of Messrs. Carels Frères, the author made complete trials on a double-cylinder 160-b h.p. Diesel engine, at the works in Ghent.

The indicated horse-power was obtained by taking indicator cards from each cylinder every five minutes during one hour, using calibrated indicator springs which gave a scale of 372 lbs. per square inch piston per inch of height.

Temperatures were taken by thermometers graduated in centrigrade degrees, that of the exhaust gases being a mean of the temperature existing quite close to the exhaust valve inside the exhaust pipe. The revolutions were recorded by a counter attached to the air-pump rods. The gases for analysis were collected over water from the exhaust pipe close to the exhaust valve, and analysis by the Orsat apparatus was made on the spot.

The effective horse-power was determined by subtracting from the indicated power the indicated power of the engine when running quite light, the driving belt being removed. This was necessary, owing to the engine being belted to a line shaft and then to a dynamo and to a motor. The load trials were each of one hour's duration, and of half-an-hour when running light. The data and results are given in the Table.

The performance of the 160-b.h.p. engine under variation of load was as follows :—

I. Load on the dynamo, 700 amp. at 115 volts, that is, 108 h.p., tachometer reading 89.

The whole load thrown off at once, the

Test of Two-Cylinder Diesel Engine at Messrs. Carels Frères, Ghent.

Summary of Results.

1. Load	Full	0·53	0·375	0·25	None
2. Duration in minutes	60	60	61	60	30
3. Total revolutions	9,258	9,424	9,639	9,476	4,770
4. Revolutions per minute	154·5	157	158	158	159
5. Mean effective pressures L	113·4	64·7	51·9	38·2	46·2
5. Mean effective pressures R	114·5	74·1	60·7	46·2	39·7
6. I.H.P. cylinder 4L	101·0	59 1	46·6	34·4	42·6
6. I.H.P. cylinder 5R	103·4	67·7	53·4	40·5	36·7
7. total or mean	204·4	126·8	100·0	74·9	39·64
8. of air pump	3·3	3·25	3·0	2·97	2·98
9. Net I.H.P. from the oil	201·1	123·6	97·0	71·93	36·66
10. Effective horse-power	164·8	87·2	60·4	35·4	—
11. Mechanical efficiency	80·7	68·8	60·4	49·2	—
12. Total oil in pounds	67·0	40·58	30·45	25·6	7·6
13. Oil per net I.H.P. hour	0·333	0·329	0·309	0·356	0·415
14. „ „ effective H.P. hour	0·408	0·465	0·505	0·724	—
15. Cooling water per minute	49·6	43·0	26·25	16·1	—
15. lbs. Inlet	9·5	9·5	9·5	9·5	10·0
16. Temperatures of water Cent. Outlet	62·0	52·5	60·5	65·5	67·0
17. Change of temperature	52·5	43·0	51·0	56·0	57·0
18. Temperature of exhaust Cent.	384·0	239·0	197·0	158·0	—
19. B.Th.U. per net I.H.P. minute	108·0	106·0	102·0	114·0	154·5
20. „ converted to work	42·4	42·4	42·4	42·4	42·4
21. „ rejected in cooling water	22·9	26·3	24·3	21·7	—
22. „ „ exhaust gases	32·1	28·3	14·4	13·5	—
23. Thermal efficiency on net I.H.P. per cent.	39·25	40·0	41·5	37·2	—
24. „ „ Eff. H.P. „	32·3	28·3	26·1	18·3	—
Exhaust gas analysis:					
25. Carbon dioxide Vol. per cent.	7·0	4·1	3·1	2·9	—
25. „ monoxide Vol. „	—	—	Trace?	0·1?	—
25. Oxygen „	11·3	15·0	16·6	17·6	—
25. Nitrogen by difference „	81·7	80·9	80·3	80·3	—

Note.—The tap of the carbon dioxide bottle was not quite gas-tight, but was well smeared with vaseline to prevent serious leakage.

tachometer ran up to 96·2 and settled back to 88·7 in about a minute.

The engine running light, tachometer 91, a load of 700 amp. at 115 volts was put on at once, when the lowest reading of the tachometer was 87·8 and the engine settled back to 90 in about half-a-minute.

The calculations from average values of the results for trial No. 2 of March 7 on the 160-b.h.p. engine are as follows :—

$$\text{Average revolutions} = \frac{9,424}{60} = 157 \text{ per min.}$$

$$\text{I.H.P. L cylinder} = 64{\cdot}7 \times 157 \times 0{\cdot}005806 = 59$$

$$\text{,, R cylinder} = 74{\cdot}1 \times 157 \times 0{\cdot}005806 = 67{\cdot}6$$

$$\text{Total I.H.P.} = 126{\cdot}6$$

$$\text{Air Pumps H.P.} = Pe \times n \times 0{\cdot}0000358 \times 2 = 291{\cdot}5 \times 157 \times 0{\cdot}0000716 = 3{\cdot}26$$

Net I.H.P., or the I.H.P. developed by the oil, $= 126{\cdot}6 - 3{\cdot}26 = 123{\cdot}34$

This assumes all the Pump H.P. returned to the working cylinder.

$$\text{Effective H.P.} = \text{I.H.P.} - 39{\cdot}6 = 126{\cdot}6 - 39{\cdot}6 = 87$$

$$\text{Mechanical Efficiency} = \frac{\text{Eff. H.P.}}{\text{I.H.P}} = \frac{87}{126{\cdot}6} = 68{\cdot}7 \text{ per cent.}$$

Pounds of oil per net I.H.P.-hour

$$= \frac{40{\cdot}58}{123{\cdot}34} = 0{\cdot}329$$

Pounds of oil per net Eff. H.P.-hour

$$= \frac{40{\cdot}58}{87} = 0{\cdot}466$$

Jacket water per minute = 43 lbs.

$$\left.\begin{matrix}\text{Thermal units per I.H.P.} \\ \text{Minute in jacket water}\end{matrix}\right\} = \frac{43 \times 43}{126{\cdot}6} \times \frac{9}{5} = 26{\cdot}3$$

Amount of exhaust gases. From the gas analysis we have :—

CO_2 4·1 per cent., O_2 15 per cent., and by difference N_2 80·9

From the well-known formula :—

$$\frac{\text{Total air}}{\text{Consumed air}} = \frac{N}{N - \frac{79}{21} \cdot O} = \frac{21}{21 - 79 \cdot \frac{O}{N}}$$

where N and O are the percentage volumes of nitrogen and oxygen in the exhaust, we get for this case—

$$\frac{\text{Total air}}{\text{Consumed air}} = \frac{21}{21 - 79 \times \frac{15}{81}} = \frac{21}{21 - 14{\cdot}6} = 3{\cdot}31$$

The approximate composition of the petroleum is—

Carbon	... ...	85·0 per cent.
Hydrogen	... ...	13·5 ,, ,,
Incombustible	...	1·5 ,, ,,

One pound of such oil would use 14·56 lbs. of air for complete combustion, calculated as below :—

Carbon	...	0·85 × 11·6 = 9·86 lbs.
Hydrogen	...	0·135 × 34·8 = 4·70 lbs.
	Total	14·56 lbs.

the resultant products being 15·56 lbs. per lb. of oil.

From the analysis, 3·31 times this air is used.

Therefore air per lb. of oil in this case gives—

$$3{\cdot}31 \times 14{\cdot}56 = 48{\cdot}2$$

The resulting products of combustion—

49·2 lbs. per lb. of oil.

Therefore weight of exhaust per I.H.P. minute—

$$= \frac{49{\cdot}2}{60} \times \frac{40{\cdot}58}{126{\cdot}6} = \frac{15{\cdot}75}{60} \text{ lbs.}$$

The specific heat at constant pressure of these gases may, with sufficient accuracy, be taken at 0·25.

Consequently the British Thermal Units per I.H.P. minute carried away by the exhaust approximate to—

$$\frac{15{\cdot}75}{60} \times 0{\cdot}25 \times 239 \times \frac{9}{5} = 28{\cdot}2 \text{ B.Th.U.}$$

Thermal units per I.H.P. minute supplied by the oil fuel

$$= 0{\cdot}329 \times 19{,}300 \div 60 = 106 \text{ B.Th.U's.}$$

Thermal units supplied per I.H.P. minute by the air

$$= \frac{15{\cdot}75 - 0{\cdot}329}{60} \times 12 \times \frac{9}{5} \times 0{\cdot}25 = 1{\cdot}4$$

Thermal equivalent of I.H.P.-minute = 42·4.

Heat Balance.

Supply 106 + 1·4.

I.H.P. mins.	...	42.4	or	39·5 per cent.
Cooling Water	...	26·3	,,	24·5 ,, ,,
Exhaust Gas	...	28·2	,,	26·3 ,, ,,
Unaccounted	...	9·1	,,	9·7 ,, ,,
		106·0		100·0 ,, ,,

Thermal efficiency on the net I.H.P.

$$= \frac{42{\cdot}4}{106} = 40 \text{ per cent.}$$

Thermal efficiency on the B.H.P. would be—

$$40 \times \frac{87}{123{\cdot}4} = 28{\cdot}3 \text{ per cent.}$$

As a check on the gas analysis results, the volume of air per lb. of oil may be approximately calculated as follows :—

The working volume of the cylinder is 2·663 cubic feet ; assuming this to be filled

Total Costs in Power Productions.

1	Means of production	Diesel Engine	Gas Engine	Steam Engine	Diesel Engine	Gas Engine	Steam Engine	Diesel Engine	Gas Engine	Steam Engine	1
2	Brake horse power	35	35	35	80	80	80	160	160	160	2
3	Size of engine house ... ... feet	12 × 20 × 15	12 × 20 × 15	10 × 20 × 15	16 × 24 × 20	16 × 24 × 20	14 × 24 × 20	20 × 27 × 20	20 × 27 × 20	17 × 27 × 20	3
4	Ground for gas-holder ... feet	—	10 × 20	—	—	11 × 24	—	—	12 × 26	—	4
5	Size of boiler house & gas-producer feet	—	8 × 16 × 12	14 × 40 × 15	—	10 × 18 × 15	15 × 46 × 20	—	10 × 20 × 16	20 × 48 × 20	5
		£	£	£	£	£	£	£	£	£	
6	Cost of land at 7s. per square yard...	10	22	30	15	29	40	21	41	56	6
7	Cost of buildings	90	130	230	140	190	360	180	235	420	7
8	Engine foundations, etc., boiler settings	10	15	60	20	28	80	35	40	100	8
9	Engine tanks, piping and condenser, etc....	585	280	240	900	635	500	1680	1140	800	9
10	Boiler or gas-producer and accessories	—	200	290	—	260	350	—	380	600	10
11	Total capital cost	695	647	850	1075	1142	1330	1916	1836	1976	11
12	Capital cost per b.h.p. ... £	19·8	18·5	24·3	13·44	14·25	16·7	14·28	11·98	12·4	12
	Annual Charges.	£	£	£	£	£	£	£	£	£	
13	Interest on capital, 4 per cent. ...	27.8	26	34	43	45·7	53·2	76·64	73·4	79	13
14	Building maintenance and depreciation, 5 per cent. ...	4·5	6·5	11·5	7	9	18	9·0	11·75	21	14
15	Engines and machinery. Maintenance and depreciation, 10 per cent.	58·5	28	24	90	63·5	50	168	114	80	15
16	Boilers. Maintenance and depreciation, 12 per cent. ...	—	—	35	—	—	42	—	—	72	16
17	Gas-producer and holder. Depreciation, 5 per cent. ...	—	10	—	—	13·0	—	—	19	—	17
18	Fuel	47·25	90	130	98	205	260	186	343	440	18
19	Lubricant, waste, etc.	20	20	20	35	35	35	55	55	55	19
20	Wages, removal of ash, etc. ...	75	90	95	75	95	110	87·5	110	140	20
21	Total	233·05	270·5	350	348	466	568·2	582	726	887	21
22	Annual cost per b.h.p. ... £	6·66	7·73	10	4·35	5.82	7·1	3·63	4.45	5.5	22
23	Cost per b.h.p. hour ... Penny	0·59	0·69	0·89	0·39	0·52	0·63	0·32	0·40	0·49	23

with air at atmospheric pressure, at each stroke we shall have for this two-cylinder engine, weight of air per revolution—

$$= 2{\cdot}663 \times 0.0809$$
$$= 0{\cdot}2163 \text{ lbs.}$$

The weight of oil used per revolution in Trial 2—

$$= \frac{40{\cdot}58}{9{,}424} = 0{\cdot}00431 \text{ lbs.}$$

$\ast^{\ast}_{\ast}$ ratio of air to oil $= \frac{0{\cdot}2163}{0.00431} = 50{\cdot}3$ as against 48·2 by the gas analysis—a difference of 4 per cent. Nothing is allowed for rise of temperature, as the air enters the cylinder.

In Fig. 4 is shown a comparison of the pressures, powers, and clearances of the three types of engine, namely, the compound condensing engine using high-pressure steam with jacketed cylinders, the scavenging type of gas engine using gas of 600 B.Th.U. per cubic foot, and the Diesel engine using crude petroleum. The indicator cards there shown are drawn to the same scales and for the same total volume of cylinder.

The clearances are as follows :—

The steam engine 3·5 per cent. of the volume of the h.-p. cylinder; the gas engine 27 per cent. of whole volume; the Diesel engine 7 per cent. of the whole volume.

The i.h.p. at 160 revolutions work out at :—

The Diesel engine . .	105
The gas engine . .	66
The steam engine . .	24 × 4 = 96

The multiplier 4 being due to the steam engine having a working stroke every stroke.

Cost of Power.

Comparison of total cost of power-production when using—

(*a*) The Diesel engine.
(*b*) The gas engine.
(*c*) The steam engine.

In Table 2 a comparative and fairly accurate statement of costs is drawn up for three sizes of engine, namely 35, 80, and 160 b.h.p.

Initial capital cost is stated for the three items, Land, Buildings, and Plant.

Annual charges are stated under the heads, Interest on Capital, Maintenance and Depreciation for Buildings, and also for Plant, Fuel, Oil and Water, and Wages.

Line 11 gives the total capital cost in £.
,, 12 ,, ,, capital cost per b.h.p. in £.
,, 21 ,, ,, the total annual expence in £.
,, 22 ,, ,, annual cost per b.h.p. in £.
,, 23 ,, ,, cost per b.h.p. hour in pence.

The gas engine taken for comparison is the Crossley, using a Dowson gas-producer. The steam engine compared with is the high-speed compound condensing engine.

The fuels are :—

For the Diesel ... Crude petroleum at 45*s.* 0*d.* per ton.
For the gas-producer Anthracite cobbles at 24*s.* 0*d.* per ton.
For the steam engine Coal at 12*s.* 6*d.* per ton.
In all cases delivered.

The oil-consumption for the Diesel has been taken, in each case, as the mean between the full and half-power rates of consumption.

The fuel-consumption in the case of the gas-producer has been taken at 1·5 to 1·25 lbs. per b.h.p.-hour plus an allowance for stand-by losses.

The fuel-consumption for the steam engine has been taken at 4 lbs. and 3·5 lbs. per b.h.p. for the lowest and highest powers; assuming an evaporation of 8 lbs. of water per lb. of fuel.

The final result is as follows :—

Total cost per B.H.P. hour.

Engines.	Diesel.	Gas.	Steam.
	Penny.	Penny.	Penny.
35 B.H.P.	0·59	0·63	0·89
80 B.H.P.	0·39	0·52	0·63
160 B.H.P.	0·32	0·40	0·49

A result which is much in favour of the Diesel engine.

H. ADE CLARK.

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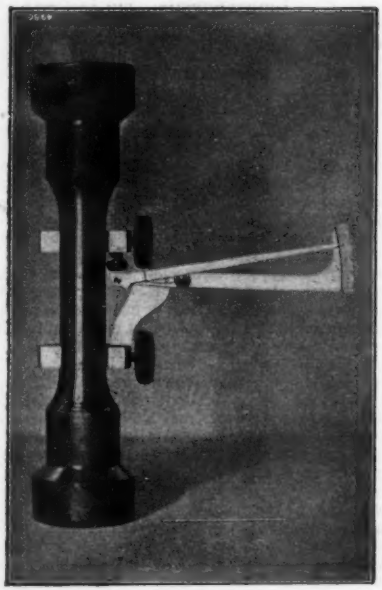
Any of the above-mentioned publications can be obtained on application to Messrs. Williams & Norgate, Henrietta Street, Covent Garden, London, W.C.

MATERIALS AND MEASUREMENTS.

A New Form of Extensometer.

THE accompanying illustration shows an instrument recently made for the test-room at the Rock Island Arsenal. This tool was made up from a Starrett test indicator, to clamp to a test specimen, to show elongation of the metal. As the piece elongates one thousandth, the pointer drops one division, and the pressure is read. In this way the test is followed up past the elastic limit, when the tool is removed and the piece broken. The curve shown in Fig 2 (reproduced on page 272) was taken from a piece of bronze. The usual readings are marked by black circles, but to show the accuracy of the instrument more readings were taken and marked by light circles. At *A* the load was removed and the curve returned to



SIMPLE FORM OF EXTENSOMETER.

the origin, *A* being under the elastic limit. At two other points the load was taken off, the curve returning to *B* and *C*, showing permanent sets of ·002 and ·005, and seeming to be somewhat stronger after having the load removed. The curves are made up in the test-room in pencil as the test proceeds, and by the time the piece is broken, the finished record is complete without further plotting. The instrument is not theoretically perfect, but is practically a success, and is one of those cases, met frequently in machine design, where a simple, direct tool giving approximate results is very much more acceptable than one more accurate, with many complicated parts. —**G. F. Summers,** *Amer. Machst., Vol. XXVI., No. 25, July 4, 1903,* p. 878.

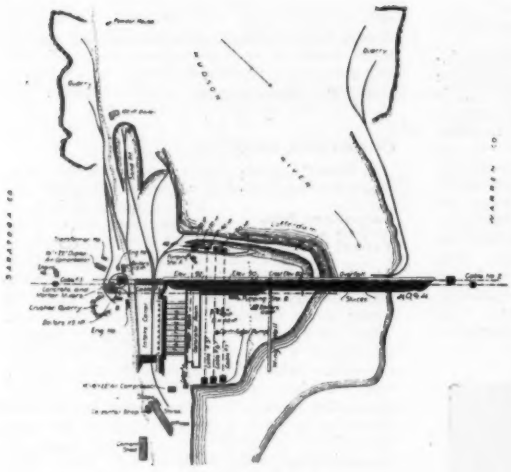
CONSTRUCTIONAL.

Foreshore Protection and Travel of Beaches.

A CAREFUL study should be made of the bed of the sea fronting the foreshore which is to be protected. Channels tend to draw the beach down into them, while sandbanks cause the waves to break and diminish their destructiveness. Again, a "gateway" between two outlying sandbanks leads the waves to the foreshore, and depletes the beach, which has thus been exposed. Groynes must be arranged so as to arrest the beach on their flood-tide side. Where cliffs above high water of spring tides are friable and subject to erosion a sea-wall constitutes a protection against the beach being driven by the force of the waves around the upper extremity of the groyne, but a sea-wall where the waves impinge upon it will by itself bring about the denudation of a foreshore. If high groynes, placed at short distances apart, abut on a wall they minimise the tendency of a sea-wall to produce a scour, as they break up the force of the wave-action. Where beach continues to advance seaward the level of the "full" does not alter. The height of these falls should not be exceeded by the height of a groyne where it terminates against a wall or cliff, unless a heavy scour on its leeward side is a matter of no importance. Spur-groynes placed on the leeward side of a breakwater or pier will be found useful in accumulating beach. The collecting capacity of any groyne may be measured in terms of its length seaward. It can be demonstrated easily that the lengthening of a groyne has produced invariably a useful and noteworthy effect, by driving back the high and low-water marks on a foreshore. Extension beyond low-water mark may best be carried out by driving sheet-piling from an overhead gantry, the gantry piles subsequently forming stays to which the sheeting is braced. In this manner groynes from 300 ft to 500 ft. in length can be constructed at a moderate outlay without serious inconvenience from loss of time.—**W. T. Douglass,** *Proc. Inst. C.E., Vol. CLIV. (Eng. Conf., Sec. II.), June, 1903.*

The Spier Falls Dam.

THERE is now building across the Hudson River at Spier Falls, a large masonry dam for power development purposes. As shown in the general plan reproduced, the structures will consist of an overfall section, on the Warren County side, 817 ft. long; a section across the river, 10 ft. and 12 ft. higher than the overfall, 552 ft. long; and, at right angles to the Saratoga County end of the river section, a dam forming one side of the intake canal, and extending in an easterly direction 403 ft. to an overfall across the end of the canal. From the intake canal, ten penstocks carry the water down to the power-house, which extends



THE SPIER FALLS DAM.

along the river bank, with one end on the dam. The dam forms a reservoir 5½ miles long and about ½ mile wide, and one foot draft on it will furnish about 100,000 h.p. hours. The head will be 80 ft., and at low water, 20,000 h.p. can be developed on a twelve-hour basis. When the storage of the upper Hudson is developed the plant can be run to its full capacity, 40,000 h.p., all the year round. The overfall section of the dam is built on a terrace about 30 ft. above the river level. The profile of its downstream face is an ogee curve, and the upstream face is slightly battered. The foundations of the dam were in all cases carried to a clean firm rock free from seams. This necessitated very extensive excavation under the spillway, as the rock here was very seamy. The power-house is a brick building, 70 ft. 10 ins. by 392 ft. inside. Across the upper end of the building is the transformer and switchboard room, and the remainder of the building is divided by the longitudinal wall into the generator and wheel rooms. The foundations are of concrete, and the rock is excavated under the building so as to give a depth of 14 ft. of tail water. Of the generators, eight are 2,500 kw. and two 2,000 kw. three-phase 2,000-volt 40-cycle revolving field alternators, direct connected to ten pairs of turbines on horizontal shafts. These wheels are 54 ins. and 42 ins. diameter, and are rated at 5,300 gross h.p. for the 42-in. wheels, under a head of 75 ft. There are two 125-volt, 150-kw. exciters, and one 125 volt, 300 kw., each driven by a separate wheel. Ducts for cables lead from the machines to a room beneath the floor at the upstream end of the building. In this room is the low-potential switchboard, from which the lines run to the transformers. There are thirty 833-kw. and seven 970-kw. air-cooled transformers. Along the river side of the building is an operating board, with all the necessary instruments and switches, so that the whole plant is under the control of one man. The transmission lines will eventually consist of five circuits designed for a 30,000-volt potential. One line leads to Glens Falls, and the others to Schenectady and Albany.—**G. E. Howe,** *Eng. Rec., Vol. XLVII. No. 26,* pp. 688-692.

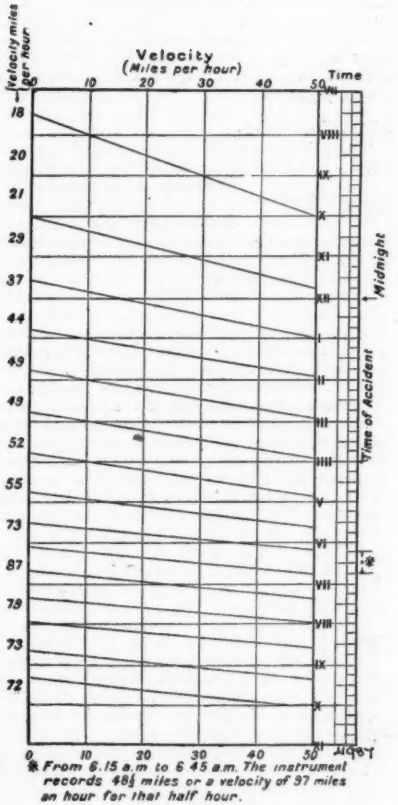
Macadam as a Core for Dams and Reservoir Embankments.

FOR temporary work, one of the editors of *Engineering News* some years ago built a small cofferdam in a quarry where it was necessary to divert a creek from the quarry site in the creek bed. Crushed stone and screenings were rammed and puddled between plank walls to form the coffer-dam, clay not being available, while the stone and screenings were right at hand. The results were satisfactory. In building a macadam core wall for a permanent dam, the use of a steam roller to consolidate the macadam would be advantageous. If the dam is too small to permit this, we have left two means by which to effect consolidation and filling of the voids: (1) ramming, and (2) puddling the screenings into the voids with water. In canvassing the permanence and the water-tightness of such a macadam core, it may be of interest to recall that macadam rolled or rammed to place and puddled with fine stone dust is really a concrete, and may have very considerable strength. Although not generally known, it is nevertheless a fact that unburned limestone dust mixed with water and slightly compressed hardens almost as if it were a cement. Dust of other stone also possesses this settling action to a greater or less degree. Felsite, for example, shows an exceedingly high cementation value according to the Massachusetts Highway Commission experiments. Even quartzite dust ranks with some of the limestones in cementing value. As yet we do not know why fine stone dust sets or "cements" when subject to pressure in the presence of water. Whatever the cause may be, the indisputable fact is that rock dust does set under suitable conditions, and it is immaterial whether it possesses this strength in virtue of physical or of chemical action, so long as the strength is there.—**The Editor,** *Eng. News, Vol. XLIX., No. 26,* p. 567.

The Leven Viaduct Accident.

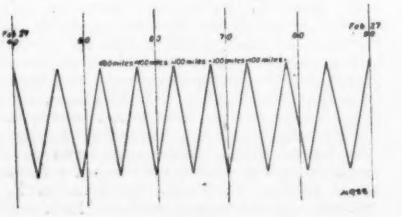
A COMPARISON between the anemometer records made by the instruments of Mr. Bent at the Heysham Harbour Works, and of Capt. Wards at Barrow, is exceedingly interesting. Barrow is about 11 miles north-west

of Heysham, and 9 miles from the scene of the accident, and Heysham is about 11 miles south of the Leven Viaduct. We reproduce in Fig. 1, a portion of the 24-hours' record at Heysham. The wind reached its maximum between 6 a.m. and 7 a.m. on the 27th February, then travelling at the rate of 97 miles an hour. At the time of the accident, the velocity of the wind is stated by Mr. Bent to have been about 55 miles an hour, which, by the formula used at Bidstone Observatory, $55^2 \div 100$, is equal to 30¼ lbs. on the square inch. Very different is the record obtained by the instrument under the charge of Capt. Wards at Barrow. A portion of the record is reproduced in Fig. 2. Roughly speaking, from 4.30 to 8 o'clock a velocity of 100 miles an hour was registered. There appears to be no reason why the velocity at Barrow should have been so much greater than that at Heysham. There seems to be good grounds for thinking, however, that the higher velocity wind reached the Leven Viaduct. We know that its force was so great that to stand upright on the viaduct was found impossible by those who extricated themselves from the overturned train. It is curious to note that although the two places, Heysham and Barrow, are so close together, the storm reached its height at such different times, though in each case the recorded maximum was practically the same, namely, 97 miles and 100 miles an hour respectively.—*Engineer, Vol. XCVI., No. 2,479*, p. 21.


Velocity (Miles per hour)
Velocity miles per hour
Time
Midnight
Time of Accident
* From 6.15 a.m. to 6.45 a.m. The instrument records 48½ miles or a velocity of 97 miles an hour for that half hour.

LEVEN VIADUCT ACCIDENT.

FIG. 1.—WIND RECORD AT HEYSHAM.



LEVEN VIADUCT ACCIDENT

FIG. 2.—WIND RECORD AT BARROW.

The Modern Equipment of Docks—Hydraulic and Electric Appliances.

If we turn to the Continent we find the change from hydraulic to electric appliances about docks is becoming almost universal. The electric transmission of power can do everything that the hydraulic transmission of power can, and a great deal more besides, and at a cheaper rate. With the same set of engines and boilers, every appliance that requires power can be driven, the workshops can be kept running and the docks can be lighted, and there is that combination of a day- and night-load which is dear to the heart of every electrical engineer. There is not very much difference between the first cost of an electric and of a hydraulic crane installation. When we look at efficiency we find that the electric crane easily surpasses the hydraulic. The following figures represent the results of a test made at Glasgow in March last on a compound 5-ton and 3-ton hydraulic crane, and a 3-ton electric crane:

Type of Crane.	Load.			
	1 ton.	2 tons.	2½ tons.	3 tons.
Hydraulic crane	236·7	236·7	236·7	236·7
Electric crane...	83·3	160·4	197·9	241·9
Ratio $\frac{H}{E}$	2.84	1·47	1·2	0·983

The relative cost of the watt-hour delivered to a crane on either system is not dealt with by the

author, but he says that even if the cost of working by electricity were slightly more, the extreme flexibility of the system would be sufficient to carry the day in its favour.—**W. Pitt,** *Proc. Inst. C. E., Vol. CLIV., Eng. Conf., Sec. II., June, 1903.*

METALLURGY.

Hollow-Pressed Axles.

THE principle of the compression of hot steel when applied to the manufacture of axles has the following advantages: (1) The net cost of the axle is lower, and with the same staff and in the same time the output is treble that obtained by the ordinary processes; (2) The resistance of the metal is increased and approaches that of nickel steel; (3) The expenses of fitting are decreased. The idea of the hollow axle is by no means new, but the methods used up to the present have proved too costly or have not yielded the desired resistance in the axle. In principle the new method differs entirely from the older ones in that it produces at one operation an axle with a solid centre and hollow ends. A cylindrical steel blank uniformly heated is inserted in a two-part die, having a matrix cavity in the form of a rough turned axle. The external diameter of the blank is equal to that of the die in the middle and at the spindles. The two halves of the die are cramped on to the heated blank, and the latter is axially perforated simultaneously at both ends by two pointed punches of 76 mm. diameter, which compress and ram the metal into the hollows of the die. This operation is conducted at a temperature of 1000 degs. C., and the effort exercised on the punch to produce its penetration is about 50 tons. Towards the end of the stroke, owing to the blank losing some of its initial heat through contact with the dies, and also to the upsetting of the end collars, at which time the metal may flow back against the punch, a total effort of 150 tons is required. The temperature of the blank should be absolutely uniform, effectual tests at Homestead have shown that the lowest temperature permitting of punching is about 850 degs. C. At this temperature the entrance of a punch is difficult and necessitates a pressure of 250 tons at the beginning and one of 500 tons at the end of the stroke. Nevertheless the axle thus made presents a good surface, and the die is exactly filled by the metal. At 950 degs. C. the final pressure necessary is not more than 250 tons, and at 1,050 degs. C. it is only 150 tons. The material of which the dies are made is best machine cast iron, water-cooled in order to prevent deformation of the cavity. Angles are filleted, and the interior coated with blacklead in order to prevent sticking. The blanks are heated in a Howard furnace, from thence passing to a straightening machine, composed of a pair of cross rolls, each roll being worked by an electric motor of 75 h.p. These rolls impart a forward and a rotating movement, which results in a perfectly cylindrical and straight blank. The diameter of the rolls being unequal, the blank is pressed against an under guide, which completely cleans its surface of scale, and delivers a smooth and clean blank to the press. On leaving the rolls, the blank is mechanically carried to a lateral transfer device, stopped by a buffer, and caused to roll into the bottom half of the die. The two halves of the die are forced together and locked, the ends of the blank pierced by the punches, which penetrate beyond the wheel seat portions, displacing the metal outwards so as to fill the cavities of the dies, giving to the wheel seat and taper portion of the axle their proper size and contour. The rear portion of the punches engage the ends of the axle blank, and force them inwardly toward the die cavity, and thus by compression shape up the ends forming the collars. The axle is removed from the die by mechanical means, and the journals and wheel seats subsequently turned up. Many trials have been made relative to the nature of the metal employed for the punch, and eventually high carbon Bessemer steel was adopted. To prevent the point of the punch welding to the axle, it is covered with a drop forged steel cap. These caps neatly fit the point of the punch, and by pressure are welded to the blank. The punch being thus protected from injury, is readily withdrawn, and after cooling is ready to receive a new cap for the next operation. To lessen the heating effect on the punches, the operation ought to be rapidly conducted, and by the special facilities employed the penetration is actually performed in from four to five seconds. As a further protection, the punches are coated with black lead. The foregoing remarks formed the basis of a memoir recently presented to the Iron and Steel Institute by M. Mercader, who thus summarises the advantages of the process: (1) The axle has a perfect form, and is excellently adapted to resist the strains to which it is subjected; (2) A saving of 33 per cent. of steel in manufacture; (3) The forging effect being both internal and external, the structure of the steel is more homogeneous than ordinary forged axles; (4) The weight of a 45-tons capacity steel car is decreased by 1·7 per cent., permitting this load, which amounts to 10 tons in a train of 40 steel cars, to be carried without any additional expenditure of energy; (5) The journals being highly compressed will, in finishing, attain a more highly polished surface, thereby diminishing friction; (6) The journals being hollow will remain colder and will permit of being used as a reservoir for oil; (7) No straightening after punching is required, the axles being as straight as the die; (8) Flaws are readily apparent, hence rough turning the axle to expose defects becomes unnecessary; (9) Finally, triple the ordinary production is obtained from the same number of hands.—**M. R.,** *Le Génie Civil, Vol. XLIII., July 11, 1903,* pp. 166-169.—*P. I.*

New Researches on Nickel Steels.

A SOFT steel of 0·12 per cent. carbon on quenching does not become fragile, but a similar steel containing up to 10 per cent. nickel, if quenched and tested by shock, appears to possess a greater fragility than ordinary carbon steel as shown in the following table:—

No.	Contents of		Annealed Steel.	Quenched Steel.
	Carbon.	Nickel.		
1	0·120	0·00	Very variable.	36
2	0·070	2·00	35	28
3	0·125	5·23	33	15
4	0 125	7·13	24	10

An interesting point is that a quenched steel containing 0 25 per cent. carbon and 10 per cent. nickel presents a very similar structure to that of an ordinary carbon steel quenched from a high temperature. When 20 per cent. nickel is reached the steel contains some γ iron, and microscopical examinations shows that the martensite appears to take a crystalline form recalling hardenite. The first experiments on the action of cold on nickel steels have shown that the foregoing martensitic structure is developed in a steel originally having a polyhedral structure by subjecting it to a temperature of −78 degs. C, whilst for other steels this transformation commences at 0 degs. C. It was, therefore, thought that by producing a temperature of −180 degs. C by means of liquid air the action would be more marked on steels which are affected by a temperature of −78 degs C., and that steels unaffected by the latter temperature would, at the lower temperature of −180 degs. C., begin to show the transformation. These surmises have been justified by actual experiment, and may be summarised as follows:—(1) Steels of 0 8 per cent. carbon and 20 per cent. nickel showed, when subjected to a temperature of −180 degs. C, a more marked decomposition than when immersed in one of −78 degs. C. only; (2) Steels 0·8 per cent. carbon and 25 per cent. nickel, on which a temperature of −78 degs. C. is without action, after immersion in liquid air show the transformation of the polyhedral structure into the martensitic one; (3) Any steel the structure of which has by any kind of treatment been changed from a polyhedral into a martensitic one cannot be improved by further treatment.—**Léon Guillet,** *Le Génie Civil, Vol. XLIII., June 27th, 1903,* pp. 134-136.—*P. L.*

A Study of Alloys suitable for Bearing Purposes.

THE author has conducted a most extensive series of tests of various bearing metal alloys from the results of which the following conclusions are drawn. (1) The rate of wear diminishes with the decrease of tin. (2) The rate of wear decreases with the increase of lead—arsenic and phosphorus apparently having no effect on the wearing qualities. In view of these results it seemed desirable to produce an alloy with as much lead and as little tin as possible, not only for the reason that such an alloy is less liable to heat in service and at the same time show a diminished rate of wear, but also because the two expensive metals, copper and tin, are replaced by the cheaper metal, lead. In experimenting towards this end it was discovered that a certain amount of tin was necessary for retaining the lead without segregation and also to give to the alloy the requisite compressive strength, but if this amount is exceeded unsatisfactory results follow. Thus alloys containing 5 per cent. tin and 30 per cent. lead were successfully made, but with the same content of lead and tin exceeding 6·5 per cent. the alloys were failures. The reason for this may possibly be found in the amount of eutectic formed. As the tin increases the eutectic correspondingly increases, and it may be readily imagined that a large bulk of the alloy cooling down from a temperature above that of the melting point of copper to 930 degs. Fah. (the solidification point of the eutectic) must necessarily remain liquid in the mould a long time. The lead has a solidifying point 300 degs. Fah. lower than that of the eutectic, and has therefore every chance, owing to its high density, to liquate to the bottom of the casting. In the absence of eutectic or in the presence of a small quantity only, solidification takes place soon after entering the mould. Where the tin is present to the extent of 5 per cent., a copper tin network is formed through the alloy which upholds or imprisons the still liquid lead, hence preventing liquation; the micro structures of these alloys consisting of a network of copper-tin enclosing large areas of mechanically held lead. Test results obtained from a series of copper-tin and copper-tin lead alloys are classified in the appended table:—

No.	Analysis.			Friction in lbs.	Tmptre. above room°F.	Wear in grams.
	Copper.	Tin.	Lead.			
1	85·76	14·90	—	13	50	0·2800
2	90·67	9·45	—	13	51	0·1768
3	95·01	4·95	—	16	52	0·0776
4	90·82	4·62	4·82	14	53	0·0542
5	85·12	4·64	10·64	18½	56	0·0380
6	81·27	5·17	14·14	18½	58	0·0327
7	75·00?	5·00?	20·00?	18½	58	0 0277
8	68·71	5·24	26·67	18	58	0·0204
9	64·34	4·70	31·22	18	44	0·0130

The conditions under which these tests were carried out were identical, and were as follows:—Total number of revolutions made, 100,000; revolutions per minute, 525; size of journal, 3¾ ins. diam. by 3½ ins. long; pressure per sq. in. in pounds, 1,000; lubrication, galena coach oil fed by cotton waste. Results obtained by following the foregoing method of alloying the lead with the copper and tin, whilst good, do not entirely meet everyday foundry conditions. For instance, the presence of accidental impurities or casting at too high a temperature may cause a slight segregation of lead, and it therefore seemed desirable to add to the alloy some metal of high melting-point which would assist the solidification. The addition of 0·5 to 1·0 per cent. nickel has been found very effective, and completely prevents any chance of segregation. A very suitable alloy for general purposes is composed of copper 64 per cent., tin 5 per cent., lead 30 per cent., and nickel 1 per cent.—**G. H. Clamer,** *Journ. Franklin Inst., Vol. CLVI., No. 1,* pp. 49-77.—*P. L.*

Malleable Cast-Iron.

WHILST the composition of a good malleable casting resembles that of a roll or car-wheel, yet the fact that it can be twisted, bent, and hammered out hot or cold, and has double the tensile strength, shows that the construction of the castings is quite different. The difference in constitution is due to the condition of the carbon. An ordinary grey iron casting contains from 3 to 3½ per cent. graphite. A malleable iron casting also contains a similar amount weighed as graphite in the analysis, but radically different in its characteristics. This form of carbon, due to annealing, has been called temper-carbon by Ledebur, who first described it in connection with the malleable process. It is essential that the casting previous to annealing should contain no graphite, that is all the carbon must be in combination with the iron. The lowest limit for carbon in the pig-iron used may be fixed at 2·75 per cent., whilst the upper limit for common work is found in the saturation point of this grade of iron, or about 4·25 per cent. The content of sulphur should not exceed 0·05 per cent, whilst that of phosphorus should be below 0·225 per cent. The content of silicon varies with the weight of the casting, and with heavy castings must be kept low in order to get a white iron in the sand. For the heaviest castings silicon should not exceed 0·45 per cent., whilst in ordinary work 0·65 per cent. is usual. Agricultural work may contain 0·80 per cent., and very light castings 1·25 per cent, which forms a limit it is not advisable to exceed. American melting practice favours the use of the reverberatory furnace, a few of the larger works employing the open-hearth type of furnace. The latter is the most economical, provided it can be continuously worked. American annealing practice differs from European, in that the latter aims for a complete removal of the carbon, whilst the former attempts its conversion from the hard carbide into temper-carbon, rather than its actual removal. The annealing process may be described by a curve which runs up quickly, remains horizontal for a time, and then gradually drops—that is, a sharp heating up in the shortest safe time possible, an even maintenance of temperature for two full days, followed by a slow cooling down to a black heat before the ovens are drawn.—**Dr. R. Moldenke,** *Journ. Amer. Foundrymen's Assocn., Vol. XII., Part I.*, pp. 1–10.—*P. L.*

The Influence of Tellurium on Brass.

MR. E. S. SPERRY, in a communication to the American Institution of Mining Engineers, dealt with the influence of tellurium on the properties of brass. To a standard alloy of 60 per cent. copper and 40 per cent. zinc tellurium was added in amounts varying from ·05 per cent. to 1·0 per cent., this addition slightly lowering the content of copper. The alloys were subsequently subjected to hot and cold working tests, from the results of which the following conclusions are drawn. The amount of tellurium ordinarily present in refined copper does not sensibly affect the rolling properties of high quality brass. If, however, the copper contains more than ·1 per cent. tellurium (which in a brass containing 60 per cent. copper gives 0·06 per cent. tellurium) the alloy has a tendency to split during rolling. The presence of tellurium does not appear to affect the quality of the brass when worked hot, thus presenting a marked contrast to copper, the hot working properties of which are destroyed by the presence of a few thousandths per cent. of tellurium.—**Dubois,** *La Revue Minéralurgique, July, 1903.*—*P. L.*

Recovery of Nickel from Scrap Anodes.

SCRAP nickel anodes are usually melted in a crucible, but by conducting the operation in a cupola the following results were obtained. The scrap melted was worth £45 11*s.* 5½*d.*; 640 lbs. of coke were used, valued at 9*s.* 4½*d.*; the cost of moulding at 12*s.* 6*d.*; labour cost at 8*s.* 4*d.*, or a total cost of £47 1*s.* 8*d.* The yield obtained represented 635 lbs. of nickel anodes worth £66 2*s.* 11*d.*, and 75 lbs. of scrap worth £3 18*s.* 3*d.*, making a profit on the operation of £22 19*s.* 5*d.*—**A. K. Beckwith,** *Journ. Amer. Foundrymen's Assocn., Vol. XII., Part I.*, p. 146.—*P. L.*

The Micro-Structure of Cast Iron.

PURE iron is built up of crystals of ferrite. As other elements are added to this iron the structure becomes involved until a point is reached when the crystals of ferrite are replaced by complex ones. Foundry irons contain appreciable quantities of elements other than iron which, with the one exception of graphite, tend to combine with the iron, forming definite compounds distinguishable under suitable magnification.—**Percy Longmuir,** *Journ. Amer. Foundrymen's Assn., Vol. XII., Part I.*, pp. 95–102.—*P. L.*

A New Cupola Slag Conveyor.

As an aid to continuous melting, the author has installed an automatic slag conveyor, composed of a series of buckets on an endless chain. These buckets, passing under the slag spout, receive the fluid slag, which quickly solidifies, and the buckets, in turning over the extreme pulley, drop the blocks into cars.—**Thos. D. West,** *Journ. Amer. Foundrymen's Assocn., Vol. XII., Part I.*, pp. 111–114.—*P. L.*

The Small Converter Process for the Manufacture of Steel Castings.

THE Tropenas Converter is supplied with two rows of tuyères placed horizontally through the side of the vessel and extending round a portion only of the circumference. It is lined with silica brick and usually has a capacity of two tons, the daily output from one converter varying from two up to 20 tons. A calculated mixture of pig-iron is melted in an ordinary cupola and transferred to the converter, the surface of the metal rising to the bottom edge of the lower row of tuyères. After filling, the vessel is inclined at a small angle, thus making the tuyères slope slightly towards the surface of the

bath, which is then blown by blast at a pressure of 3 lbs. During the first stage of the blow the lower tuyères only are used. Oxidation commences, and the silicon is eliminated whilst the carbon is converted from the free into the combined condition. When, by the combustion of the silicon the temperature has been raised to a certain point carbon and manganese commence to oxidise, and on the appearance of the carbon flame the upper tuyères are opened. The carbon partially consumed by the lower tuyères is supplied with supplementary oxygen from the upper ones and completely burned to CO_2, generating further heat, which is absorbed by the bath. This forms one of the important features of the Tropenas process, rendering the steel exceedingly hot and fluid, and therefore very suitable for light castings. The blow occupies about 20 minutes, and on its termination the converter contains a bath of practically pure iron. Recarbonisation is made in the converter if the entire heat is desired of the same composition or in individual ladles if different tempers are required. The following table shows the changes taking place during the blow :—

	Cupola Metal.	After 5 minutes blowing.	After 12 minutes blowing.	After 14 minutes blowing.	After 18 minutes blowing.	End of Blow.	After final addition.
Graphite	3·180	2·920	—	—	—	—	—
Combined Carbon	0·350	0·340	2·900	2·300	0·860	0·100	0·240
Silicon	2·310	1·620	0·466	0·382	0·084	0·074	0·326
Sulphur	0·037	0·037	0·035	0·036	0·038	0·038	0·037
Phosphorus ...	0·054	0·053	0·054	0·054	0·051	0·050	0·058
Manganese ...	0·610	0·600	0·101	0·040	0·040	0·042	1·080

Arthur Simonson, "*The Foundry*," *July, 1903*, pp. 189-192.—*P.L.*

Iron and Hydrogen.

THE authors give some tables recording the results of experiments relative to hydrogen alloys, the table below giving result of hydrogen-iron combination.

	1 vol. of metal absorbs vol. of hydrogen.	1 gr. of metal absorbs hydrogen. ccm.	1 gr. of metal absorbs hydrogen. mg.
English Hæmatite Pig-Iron	0·018	0·002	0·0002
German Hæmatite Pig-Iron	0·062	0·009	0·0008
Grey Pig-Iron (at 800°)	0·63	0·088	0·0079
Pig-Iron from Converter	0·227	0·030	0·0027
Ingot Iron (Basic Metal)	0·129	0·016	0·0014
Ingots from Martin Furnace	2·8—3·7	0·36—0·48	0·033—0·043
Welding-Iron ...	0·15—1·6	0·02—0·2	0·0018-0·017
Galvanically Deposited Iron ...	up to 248	32	2·8

Many experimenters have dealt with the absorption of hydrogen by other metals, Müller's experiments (1882) having given rise to further investigations of the hydrogen alloys of iron. By absorbing hydrogen, galvanic iron will assume a greater hardness, the gas thus absorbed being given off completely at a temperature of 99° C. When heated up to higher temperatures, however, iron recovers its capacity for absorbing hydrogen, a maximum corresponding with a temperature of about 800°, as shown by Heyn. This hydrogen is given off, when cooled slowly, but not by chilling. As, however, fused iron is found to contain very great amounts of hydrogen, the existence of a second maximum may be anticipated.

As regards the state of hydrogen in iron, the authors adopt the hypothesis of ordinary alloys being formed, which, however, are decomposed readily at ordinary temperatures. According to Graham, as is known, hydrogen would be the vapour of a metal, the non-metallic properties exhibited by solidified hydrogen (−258°t) being no evidence of the contrary, as the carbon of iron and that taking the form of diamonds equally show quite different properties. With regard to the influence of the composition of the iron on the phenomena in question, the authors state that the presence of silicon prevents the liberation of the hydrogen alloyed to iron. High percentages of carbon will diminish the absorption of hydrogen, whereas manganese, and very likely, nickel and cobalt, exert an inverse effect.—**Dr. Wedding** and **Dr. Th. Fischer,** Paper read before the Berlin Congress for Applied Chemistry, *June 1903*; *Stahl und Eisen, XXIII., No. 13*, pp. 798-799, *July 1, 1903*.—*A.G.*

The Physical Properties of Malleable Cast Iron as Influenced by the Process of Manufacture.

IN a memoir presented to the American Society for Testing Materials, the author urges the necessity of a special clause in the specifications for "malleable cast iron," limiting the processes allowable in its manufacture. The necessity for this action is found in the recent developments of the heat treatment of cast iron. By subjecting the hard casting to a much higher temperature than that usually employed, the time of annealing is considerably shortened, but the properties of the casting are not so reliable as those annealed in the ordinary manner. Therefore, until knowledge

of the heat treatment of cast iron is more extensive, it will be well to demand in specifications of malleable cast iron that the castings have been annealed for a minimum number of hours at the usual temperature. For light work this minimum might be placed at 60 hours, and for ordinary or heavy castings at 72 hours.—**Dr. R. Moldenke,** *Eng. News, Vol. L., No. 2,* p. 45.—*P. L.*

Temperature Reactions in the Blast Furnace.

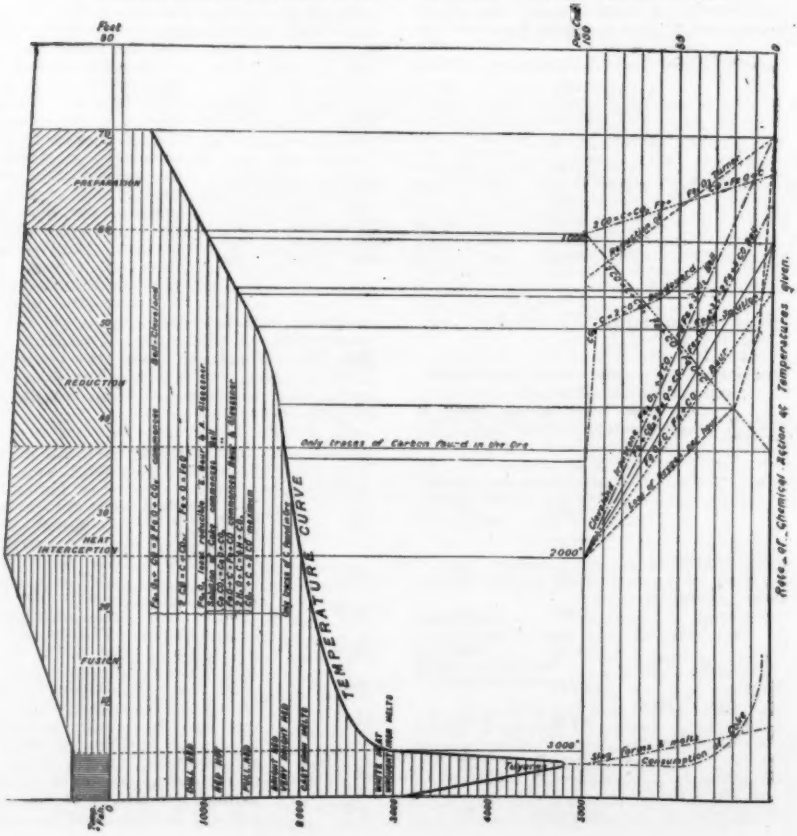
In the accompanying diagram the blast furnace "zones" are shown, and the temperature at which the various reactions take place. This chart has been constructed on results obtained chiefly from Cleveland ore smelted with coke fuel and limestone flux, but, as an examination will show, it is practically a constant for almost any type of blast furnace. The chemical reactions, and their rate at different temperatures, are clearly indicated by the portion of the diagram marked "Percentages," showing also the chemical action occurring in the various zones of the furnace. The rapid increase of heat intensity in the hearth of the furnace is forcibly shown in the temperature curve, which also indicates the portions of the furnace structure requiring protection by water cooling. — **H. Allen,** *The Engineer, July 24, 1903,* pp. 84, 85. —*P. L.*

PRIME MOVERS.

Tests of a Gas Engine.

With the hope of being able to contribute something to the better understanding of the relations of some of the factors of the problem for the Otto-cycle gas engine, an investigation was begun in the laboratories of Purdue University in 1896, and

TEMPERATURE REACTIONS IN THE BLAST FURNACE



has been continued since that time. The difficulties of an investigation of the sort here reported may be better appreciated, perhaps, when it is known that no very satisfactory advance in the problem as a whole was made until the fourth year of investigation. In the attempt during the fifth year to verify the results of the fourth, a number of contradictions were met which necessitated a sixth year's work in order to determine which of the two previous years' records should be accepted. From the records now presented it appears: (1) From the standpoint of the indicated horse-power, the lowest gas consumption and the highest thermal efficiency are secured under the following conditions: Ignition between normal and late, jacket temperature, the lowest used, or 90 degrees; speed, the lowest tried, or 150 revolutions per minute; brake horse-power at about 0·6, the normal capacity of the engine. (2) From the practical standpoint of gas economy and thermal efficiency based upon brake horse-power, the frictional horse-power is an exceedingly important factor, being in many cases sufficient to more than counterbalance decided thermal disadvantages. The lowest frictional horse-power and the highest mechanical efficiency are secured with late ignition, high jacket temperature, low speed, and the highest horse-powers available under the conditions thus defined. (3) The importance of friction as a factor in realising high thermal efficiency based upon brake horse-power, is emphasised by the fact that the highest efficiency is secured under substantially the same conditions as specified in (2) for obtaining the least amount of friction and the highest mechanical efficiency.—**C. H. Robertson,** *Trans. Am. Soc. Mech. Eng., Vol. XXIV., June, 1903.*

Steam Engines and Superheated Steam.

In determining the advantages to be obtained from superheating, it should be understood that it is not sufficient to compare the consumption of saturated and superheated steam. The general working of an installation ought to be studied, and the mean cost per horse-power should be taken as the basis of comparison. In order to give the results of his experiments every guarantee of his authenticity, the author obtained the co-operation of Prof. Shröter, of l'École Polytechnique de Munich, and of M. Vinçotte, Directeur de l'Association pour la Surveillance des Chaudières, two recognised authorities in connection with engine trials. All the figures obtained have been recorded in tables, and curves have been traced showing the consumption of steam. The first conclusion to be drawn from these trials is that economical engines, when worked with superheated steam, maintain their advantages over wasteful engines. Nevertheless it appears that superheating is of benefit chiefly to inferior types of engines. As shown by the various tables given by the author, the economy of superheated steam as compared with saturated steam amounts to 20 p.c. up to 300 degs. C., and to 30 p.c. at 350 degs. C.; but these are the apparent economies, for it is the consumption of heat that must be considered. Superheated steam contains more heat units than saturated steam, and naturally requires more fuel for its production. Therefore, in order to ascertain the net gain, it is necessary to compare the quantities of heat consumed per h.p. By plotting the curve of superheated steam consumption, in this manner comparison may easily be made with the relative curve of saturated steam, and the net economy then becomes evident, and as shown by the tables the net economy at 300 degs. C. is about 10 p.c., and at 350 degs. C. about 15 p.c. The diagrams traced by the author indicate a very simple law, which, if not quite exact, is approximately correct, viz., The economy due to superheating, as also the reduction of steam consumption, is proportional to the degree of superheat. This law is true up to 350 degs. C., but above that point, and especially above 375 degs. C., the increase of economy decreases with the increase of temperature. The law shows, however, that it is a mistake to limit superheating to 250 degs. C. if the power produced be alone considered; there is clearly an advantage in going as far as 350 degs. C. in compound engines.—**A. Vanderstegen,** *Annales de l Assoc. des Ing. de Gand. Tome II.* pp. 1–27.

Some Recent Forms of Gas Producer.

The water-bottom type of producer has become general, and very few of any other kind are now built. In the early days of producers two well-marked types were in use—the bar-bottom and the centre-blown. Both types are still used, modified so as to allow of the use of the water-bottom. Of the bar-bottom producers the best known and most successful is that of Mr. Duff. In this producer the air and steam are blown under bars placed in the form of an inverted **V**, so as to slope in both directions, and allow the ashes to slide down into the water-trough on each side. The latest of the centre-blown converters is that of Messrs. Smith and Wincott, in which air and steam enter the producer horizontally, and are thus very uniformly distributed. The hottest region of the producer is in the centre, and, the air and steam openings being vertical or sloping backwards, ash and fuel cannot possibly rest on them and choke them. This producer, therefore, allows of the use of almost any fuel. A new type of producer has been introduced by Messrs. Duff and Whitefield. In this the air, with a small quantity of steam, is delivered under the grate, and the gas is drawn off from about half-way up the producer, instead of from the top. From the upper part of the producer a series of openings at different levels lead to vertical mains, which, by means of horizontal pipes, open again into the producer near the bottom. A steam jet blows into the vertical tubes, and enough hot gas is thus drawn up through the fuel to distil off all volatile matters. These are carried forward, mixed with steam, into the incandescent fuel, which, being at a high temperature, breaks up the tarry matters into a fixed carbon (which is consumed) and permanent gases, the steam of the steam jet being also decomposed, and any carbon dioxide found at the comparatively low temperature of the upper part of the producer

is converted into carbon-monoxide. Thus a gas is obtained which is quite free from tarry matters. When the gas is to be used for gas-engines it is passed through a superheater, then through a coke sculler to wash out any dust, and through sawdust drying boxes. Up to the present gas for gas-engines has almost always been made in producers using coke as fuel; but by this new type of producer the difficulty of preparing a good gas of high calorific power from coal, without the use of very elaborate cleansing apparatus, seems to have been solved.—**A. H. Sexton,** *Prac. Eng., Vol. XXVII., No. 853,* pp. 7–9.

Positive Governor Drives for Corliss Engines.

In *Machinery*, March, 1899, was an article by the writer on "The Corliss Governor and Fly-wheel Accidents," in which were tabulated some of the Corliss engine accidents that had occurred attributable to the governor belt. At the same time it was recommended that belts be replaced by positive drives. Since then he has fitted positive drives to three large power engines and two large ice machines with gratifying results. In the former case, before putting on the positive drive, the governor belts were a continual source of trouble and anxiety. It was impossible to keep oil from the belts. It was difficult to cut two generators in together, and still more so to cut three generators in together, while it was no uncommon thing for the circuit breakers to fly out, owing to poor engine regulation. This trouble has ceased since the positive governor drives were installed. The generators can be easily and quickly cut in together, while they adjust themselves much more quickly to their proportionate load. The engineers and oilers appreciate fully the improved working conditions of the engines and generators. The gears are cut steel gears, and run very quietly. In the ice machine drives two Ball ice machines were fitted with cut steel sprockets and "Morse Rocker Joint" chain. Here, again, there was always trouble with an oily, slack governor belt. Since the chain drives were substituted for the belt drives the machines run more steadily at all speeds from 17 to 75 revolutions per minute. The chain drive has some points of advantage over the geared drive. It is cheaper to instal, it is not affected by any slackness or wear of the main bearing, it requires less attention, and runs more quietly. The chain drive could be easily applied to throttling governors. A greasy belt on a throttling engine, a runaway engine and a dead engineer, is the tale of a recent accident. Most Corliss engine-builders advertise their so-called safety stop, but in spite of the stops the engines frequently fail to stop until after the wreck. The danger is not where a belt breaks and allows the safety device to work, but where the oily belt slips and does not keep the governor up to speed, allowing a longer range of cut-off than is necessary to care for the load, in which case the engine soon speeds up to the danger line.—**A. H. Eldredge,** *Trans. Am. Soc. Mech. Eng., Vol. XXIV., June, 1903.*

Steam-Driven and Gas-Driven Blowing-Engines.

It recently became evident that blowing-engines worked with gas are particularly suitable for blast-furnace work. The author, therefore, investigated the matter fully and carefully, and finally made arrangements with the Société John Cockerill to build gas-driven blowing-engines under their patents, with double-acting gas-cylinders, for blowing and dynamo-work. He says that the gas-engine is more suitable than the steam-engine for blowing purposes, providing always there is a ready means of using the gas which will be saved by using the gas-engine. If an entirely new steel-works, with blast-furnaces, etc., is to be put down, undoubtedly the whole of the blowing power for the furnaces should be derived from gas; and it will be found that there is a considerable surplus which can be sent to the steel works, boilers, or used for gas-engines to generate electricity, but if a blast furnace plant is to be erected without steel or other works, and there are no other outlets for surplus power, there is probably not much difference between using steam-driven or gas-driven blowing-engines. The question between steam-driven and gas-driven blowing-engines is more open for consideration where existing works requiring increased blowing-power have to be dealt with, and then it would turn largely upon a question of existing boilers, condensers, etc. If these are ample and in good condition, and there is no easily-found means of using surplus power, many people would prefer to put down steam blowing-engines; but if a condenser and new boilers have to be put down, it would appear to be wiser, instead of using steam-blowing engines, to adopt gas-driven engines. To consider the whole question it may safely be assumed that the quantity of gas used by gas-driven engines would be about one-fourth that required to raise steam in good boilers for steam-driven blowing-engines. It may also be considered that broadly the cost of a steam-driven blowing-engine of modern construction, together with the necessary boilers, condensing plant, etc., will be somewhat more than that of gas-driven blowing-engines with the necessary gas-cleaning plant, for a given amount of work to be done.—**T. Westgarth,** *Proc. Inst. C.E., Vol. CLIV., Eng. Conf., Sec. IV., June, 1903.*

A New Theory of Heat-power Plants.

These articles are an effort to contribute towards presenting the relation of heat to mechanics in a form which is more complete than that developed by the scientific men of fifty years ago. The thermodynamics of the pure scientist have certainly done much towards helping us to understand the influence of temperature; but as temperature is only one influence that forces itself into the design of heat machinery, the result is that the development of power plant has been guided only in a secondary degree by the maxims of the thermodynamic treatises. Present theory seems to be deficient in three main directions. First, it loses sight of the fact that heat is of use solely as a means of creating *resilience*—that it is resilience that does all the work, and that

stress, along with *unstraining*, are the two only factors of direct consequence in the engineering of mechanical power. Secondly, it contains no reference to the *time-element*. Thirdly, the "thermodynamic efficiency" is only one of many equally important factors, and the complete solution of the problem of maximum energy is found in the proper combination of several partial solutions. In the present article the writer devotes attention to a consideration of resilience, classifying the kinds of resilient mechanical energy as—(*a*) expansive, or thermal; (*b*) tentative, or molecular cohesive; (*c*) torsional, or dependent on molecular rigidity; (*d*) gravitational; (*e*) magnetic; and possibly (*f*) electrostatic. He shows that the resilient transmission of energy may be positive or negative, the direction of transmission being related to that of motion in the three cases of compression, tension, and torsion.—**Prof. R. H. Smith,** *The Engineer, Vol. XCVI., No. 2480, July 10, 1903,* pp. 34, 35.

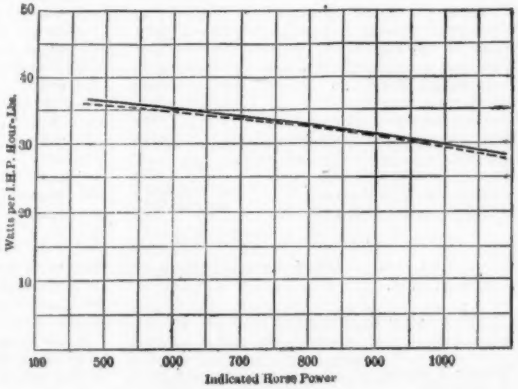
Steam Engines made in the United States.

In this issue is presented what is probably the best and most complete description that has ever been published of steam engines manufactured in the United States. It contains the following articles:—Corliss Engines, by George G. Phillips; Low and Medium-Speed Engines, by J. W. Thompson; High-Speed Engines, by Charles T Porter; and The Selection of Engines, by Prof. R. H. Thurston. All matter has been revised with the co-operation of the manufacturers, and the issue is one that will furnish to the working engineer all necessary information with regard to the construction and care of any engine he is likely to meet. *The Engineer (U.S.A.), Vol XL., No. 12,* pp. 420–503.

TRACTION.

Piston v. Slide Valves.

With the object of determining the relation of piston and Richardson slide valves in respect of water consumption, an elaborate series of tests has been carried out upon the Lake Shore and Michigan Southern Railway. Eighteen tests were made with the piston valve, and twenty with the slide valve. The two engines used were of the 4-6-0 type, identical in every respect as to the valve motion, No. 600 being equipped with the Allen-Richardson balanced slide valve, while No. 611 had the direct-motion inside-admission piston-valve, the principal dimensions being 20-in. by 28-in. cylinders; 6-ft. 8-in. driving-wheels; weight on coupled wheels, 59 tons 7 cwts. 2 qrs.; total weight, 76¾ tons; heating surface, 2·862 sq. ft.; grate area, 33·5 sq. ft. The distance over which the tests were made was 143 mls. To determine the i.h.p., indicator cards were taken every minute throughout the runs. The speed was taken by a revolution counter, which was checked by mile-posts, and found correct. Water measurements were taken by gauges placed in the corners of the tank, the readings being corrected to give the depth of the centre of gravity of the surface of the water. By subsequently calibrating the tank for each inch of height on track scales, this method of measurement was checked. Coal was weighed on the tender by track scales. The tests were equally divided on each side of the engine. No allowance was made for the steam consumed by the air pumps, the loss at pop valves or water lost at the injector overflows. For several runs the cylinder tractive power was plotted, and the total foot-pounds of work were found from the diagram, but it was found to vary so little from the average indicated horse-power that the latter was used in subsequent tests. The dotted curve on the diagram is that of engine No. 611, with piston valves. These curves are interesting because they show remarkably uniform results from road tests, and there is little doubt as to the accuracy of the curves drawn to represent the average results. The piston-valve engine is slightly more economical than the one with slide valves, but by amounts varying only from 1 to 1½ lbs. of water per h.p. per hour, say 3 to 4½ per cent. This is probably due to decreased compression in the piston-valve engine, which is shown in the indicator diagrams. These also demonstrate that the steam line is better maintained on the slide-valve engine, the exhaust line being, however, better on the piston-valve engine. The tests are interesting also from the large amount of power developed, each engine having averaged over 1,000 h.p. for the entire distance of 143 miles. The evaporative efficiency is low and the reason



PISTON *v.* SLIDE VALVES.

DOTTED CURVE REPRESENTS THE PISTON-VALVE ENGINE.

for this is not yet determined. The coal burned per foot of grate is high, and it is evident that the work developed is all that could be expected from the engines.

PISTON *V.* SLIDE VALVES.
AVERAGE RESULTS.

	Piston.	Slide.
Engine number	611	600
Duration of steam in minutes ...	161	155
Tonnage behind tender	317	327
Ton miles	45,400	46,700
Average speed, deducting stops ...	50·0	49·2
Ton (miles per hour)	15,400	16,100
Average indicated h p.	838	795
H.p. hours	2,160	1,990
Total coal	13,430	13,600
Total water	68,400	69,430
Water per pound coal	5·33	5·10
Water per h.p. hour	31·7	34·9
Water per ton mile	1·51	1·49
Water per ton miles per hour ...	4·16	4·30
Coal per h.p. hour	6·23	6·83
Coal per ton mile	·296	·291
Coal per ton miles per hour	·872	·845
Water per sq. ft. heating surface hour	9·28	9·27
Coal per sq. ft. grate area per hour...	143·	162·5
Average tractive pull from cards ...	5,680	5,480
Average cut-off in inches	8·52	7·49
Average opening of throttle	·157	·123

Amer. Eng. and Railroad Journ., July, 1903, p. 260—*C. S. L.*

Energy Losses on Electric Cars.

THE accompanying diagrams show the distribution of losses on an electric car, and a study of these may suggest ways of effecting increased running efficiency. The curves (Fig. 1) have been calculated to represent the speed and energy consumption of an electric railway car weighing about 28 tons, making runs averaging half-a-mile in length. The curve *w x y z* indicates the speed of the car on the level. The first part of the curve *w x* forms the line of acceleration, and represents the gradually-increasing speed of the car during the period of 55 seconds when energy is being supplied to the motor, as shown in the full line curve. The necessary data for constructing these curves is obtained from the speed and tractive effort curves of the motor. For the next 35 seconds the car is allowed to coast, when the speed falls as shown by the line *x y*. The operation of braking occupies the following 18 seconds, during which the car is gradually brought to a rest at an average rate of retardation of one mile per hour per second. The area of speed curve *w x y z* represents distance covered, being the product of velocity and time. The area of energy curve made up of sections *A, B, C, D* and *E* represents electrical energy in units, vertical distances being proportional to the rate of input in k.w., and horizontal distances to time in seconds. The bulk of the waste energy is accounted for by the process of starting and stopping, and the more frequent the stops the lower the running efficiency of the car. If the number of stops is fixed the lost energy *D* remains fairly constant and cannot be greatly lessened. It is possible, however, to decrease the loss *E E* by increasing the period of coasting, in this way making a greater part of the kinetic energy available for moving the car. Such an alteration will affect the average speed of the car, as shown in Fig 2. By comparing Figs. 1 and 2 it will be seen that, owing to the large amount of coasting allowed in Fig. 2, section *C* practically vanishes, and section *B* absorbs a large part of section *E*, as appears in Fig. 1. It is thus apparent

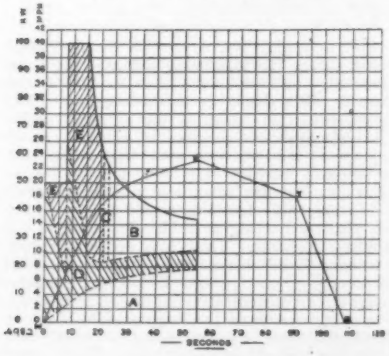


FIG. 1.

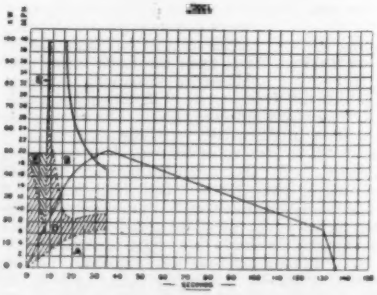


FIG. 2.

ENERGY LOSSES ON ELECTRIC CARS.

that the ratio of unshaded to shaded sections in Fig. 2 is greater than in Fig. 1, and consequently the efficiency is also greater. The curves show that the maximum car efficiency, considered mechanically and electrically, is obtained when the number of stops are as few as possible, and when as much coasting as the schedule will permit precedes these stops.—**W. Park,** *Tram. & Rly. Wld., June 11th, 1903*, pp. 543–544.

Magnetic Increase of Traction.

In a comparatively recent invention electro-magnetism has been tried as a substitute for sand to increase tractive power. A simple magnet is used connected with what is termed an idler wheel. The operation of the system is as follows:—When applied to an ordinary trolley car on each side of the motor, between the motor casing and the wheel, is a bearing which supports an arm, upon which the magnetising coil of wire is wound. The other end of the arm carries a small wheel without any flange, which rolls along the rail when the device is in operation, and is held above the rails by springs when the coil is not energised. The object of this arrangement of an idler wheel upon the rail is to give a short magnetic circuit. The lines of force in this case flow from the arm to the car journal and wheel, from the wheel to the rail, from the latter to the idler wheel, and thence to the coil-wound arm. Experiments have been conducted with this method of increasing traction on both street and steam railroads. A double-truck car was equipped with two 50-h.p. motors for driving purposes, also for supplying what might be called the traction current. The idler wheels were held at a distance of five-eighths of an inch above the rail when the magnet was not energised. The current was controlled by a switch. It was found that, with an expenditure of 2½ h.p., the magnetism developed increased the tractive effort over 300 per cent. In one instance the wheels and rails were greased, and the car started. When the wheels began to slip the draw-bar pull was found to be 1,500 lbs.; when the magnets were energised this was increased to 5,250 lbs. In another test the model of a trolley car, by use of the device, was moved up a track constructed at an incline of 45 degs. When the current was turned off the magnet, however, the ascent was found to be impossible.—*Elec. World & Enginr. (N. Y.), Vol. XLI., No. 26, 1903*, p. 1102.—*C. S. L.*

Motor Vans for Municipal purposes.

The author is strongly of opinion that, should the cost of working motor vehicles even approximate to that of horse-drawn ones, every local authority responsible for cleansing the streets should encourage their use, both on sanitary and economical grounds. Some account should also be taken of the very heavy wear and tear to the road surface caused by horses' feet, which would to a great extent be obviated if mechanically propelled vehicles were in use. What has been termed the "three-hundredweight hammers of iron-shod horses' feet," probably wear out every road twice as quickly as the iron-shod wheels of the vehicle which they draw. There is no doubt that the motorvan industry is sorely crippled by the 3-ton limit. A somewhat heavier vehicle would not do any more damage to the road than one within the 3-ton limit. The author has had at work a steam motor-van which has a frame built to take either a tipping body, or a water tank. This machine has proved very useful and economical. The use of such a vehicle is greatly to be recommended, and the author finds that by a simple arrangement he can fasten a horse broom to it, and thus water and sweep at the same time. Motor vehicles have many advantages, but when used for street-cleansing or dust removal the wages of the skilled mechanics who drive them adds greatly to the cost. If the motor-driver were able to walk alongside his vehicle like a horse carman does, or if an unskilled man could drive a dust-motor and leave it unattended while he collected the dust, motor cartage would be cheaper than horse cartage. But at present this cannot be done. Thus it is found that a motor which has to crawl along from door to door for dusting, or from heap to heap for slopping, is being used in the most unprofitable manner possible.—**T. W. E. Higgens,** *Pub. Health Eng., Vol. XII., No. 320*, pp. 677–678.

Grades and Climbing.

In the matter of climbing a grade a locomotive is doing work which may conveniently be resolved into two components. There is the resistance of the train due to rolling friction along the level, and there is the work of lifting the train through a given vertical distance. The value of resistance due to rolling friction along a level road is given by Forney as 6·6 lbs. resistance per ton (2,000 lbs. American) weight of train, at a speed of 10 miles per hour. This value remains constant for that speed whether the train be moving along straight-level track or going-up grade. This resistance, however, increases with increased speed. The pull of a locomotive on a grade is exerted through the horizontal distance of one mile. If one ton is lifted 211 ft. while being pulled a mile, the rule which applies in finding the resistance per ton for the grade is multiply the weight of the train in pounds by the ascent in any given distance in feet. Applying this to the case before us, we have—

$$\frac{2{,}000 \times 211}{5{,}280} = 79{\cdot}9 \text{ lbs.}$$

That is 79·9 lbs. resistance for every ton weight of train due to the grade. To this must be added the 6·6 lbs. per ton due to rolling friction at a speed of ten miles an hour. The total resistance per ton that must be overcome to get a train up a 4 per cent. grade at ten miles per hour is 86·5 lbs. In this calculation no account has been taken of curves or of wind resistance, or of slewed trucks with cutting-wheel flanges due to poor centre plates and side bearings. A steady pull on a straight track in good condition, and in perfectly calm weather are the only circumstances taken into account — *Raily. and Loco. Enging. (Editorial), 1903, July*, p. 312.—*C. S. L.*

Superheaters for Locomotives.

THE author thinks the main drawback with existing types of superheaters for locomotives to be the fact that the steam is superheated on its passage through pipes; two laws, in fact, will counterbalance the effect of superheating, viz., first, the decrease in the speed of the steam from the middle of the pipes to the walls, *i.e.*, the heating surfaces, and, second, the low thermic conductivity of superheated steam, it thus being difficult to supply the core of the stream with heat. As, on the other hand, the effect of superheat is due to a diminution of the condensation in the cylinders, the whole of the steam should be superheated just so much as to prevent condensation, instead of using high temperatures in connection with partial superheat. The superheater designed by the author allows of the steam being mixed in a most intimate way; it is made up of one or two cylindrical vessels traversed by straight and extremely thin-walled heating pipes, arranged at the same mutual distance as the heating pipes of the longitudinal boiler. The superheater may, therefore, be placed in the midst of the smoke-box, *i.e.*, in the mainstream of the hot gases, without interfering with the cleaning of the boiler-pipes. As the gases in the case of the exhauster being out of work will mainly rise before reaching the superheater, an excessive heating of the pipes, while the locomotive is stopped, is made impossible. In order to obviate the different wear and tear of the walls of the pipes, the superheating drums may be built in in six different positions. A further advantage is afforded by the comparatively small resistance of the pipes situated in the corners, their heating surface thus being better utilised.—**L. V. Low,** *Dingler's Polytechnisches Journal, Vol. 318, No. 28, 1903,* pp. 440–441.—*A. G.*

MECHANICAL.

The Testing and Accurate Cutting of Screws.

MUCH thought has been expended in the effort to produce a perfect leading screw, but most makers are content if the screws cut by them are approximately correct in terms of absolute length, and do not trouble much about variation in pitch. In ordinary circumstances it is satisfactory if the screw cut in the lathe approaches the leading screw in accuracy; but there are circumstances in which the screw turned out may be more accurate than the leading screw itself. If the lathe has two carriages, it is possible to make the various inaccuracies of pitch counteract one another by making use of the nuts of both carriages while cutting with one tool only. In the first place, the leading screw must be tested and a diagram laid down to a convenient scale showing the various inaccuracies of pitch as in Fig. 1. From a study of this figure it will be found that if the carriages are set at a distance apart so that the pitch of the nuts will be equal to A B, then throughout the curve the rise will tend to counteract the fall. The carriages are therefore set at a distance apart, and then bound together by stiff bars, the nut of one carriage is dropped full in gear with the screw, while the other nut is allowed just a little play, so that where the disparity of pitch is excessive the wheels in the fast head may not be unduly stressed. When the screw operated upon has been roughed out, it is tested and a diagram made as for the leading screw. The second diagram is placed directly over the first, and a study of both will show how far the result aimed at has been obtained. If reasonable care has been taken it will be found that when the screw is finished the variations in pitch are very slight indeed.—**A. J. Orr,** *Mech. Wld, Vol. XXXIII., No. 859,* p. 295.

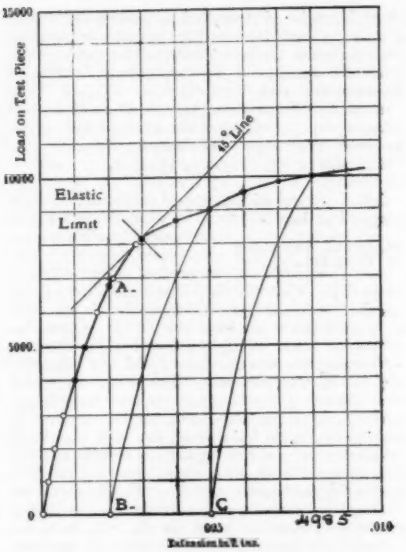


FIG. 2.—NEW FORM OF EXTENSOMETER (SEE PAGE 259).

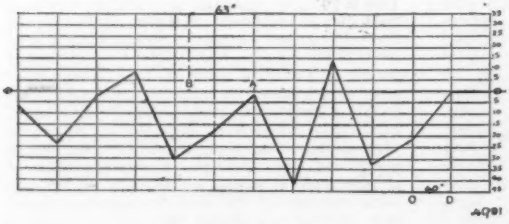


FIG. 1.—TESTING SCREWS

The Riveting of lapped Butts.

In the second part of a paper dealing with the construction of large steel steamers the author says that the strength of a butt is equal to the strength of the plate through the endmost row of rivets, the spacing of which is determined by the thickness of the plate. The thicker the plate, the greater can be the distance between the rivets for sound caulking, and it perhaps is a matter of opinion what this spacing should be. Table I. has been compiled showing the percentage of strength at various places in the butt, for each thickness of plate from $\frac{5}{10}$ to $\frac{20}{10}$ of an inch. Table II. shows the corresponding arrangement of rivets in each butt. The lap-butts shown on the tables have been calculated under tensile stress, but these butts, especially at midships, are continuously subjected to compression as well as tension. If it is desired to make the lap-butt when under compression equal in strength to the solid plate, more rivets are required; the number per space of rivets on the endmost rows for each thickness is given in Table II. — **A. Hogg,** *Trans. N.E. Coast, Inst. Eng. & Shipbuilders, Vol. XIX., Pt.* 7, pp. 185—200.

TABLE I.

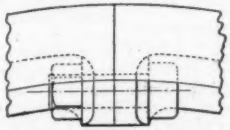
Thickness of Plate in 20ths of an Inch.	Dia. of Rivets in Inches.	Strengths. Solid Plate.	Punched Plate at Edge Row.	Countersunk Plate at Edge Row.	Shearing of Rivets.	Bearing of Plate.	Punched Plate at 2nd Row and Shearing Edge Row Rivets.
5	$\frac{5}{8}$	100	62	66	80	66	—
6	$\frac{3}{4}$	100	62	66	78	65	—
7	$\frac{7}{8}$	100	62	66	66	65	—
8	$\frac{7}{8}$	100	65	71	75	84	—
9	$\frac{7}{8}$	100	65	71	78	85	—
10	$\frac{7}{8}$	100	66	72	74	91	89
11	$\frac{7}{8}$	100	68	74	75	101	93
12	$\frac{7}{8}$	100	69	76	79	115	80
13	1	100	66	73	78	109	87
14	1	100	68	75	78	118	81
15	1	100	69	76	78	125	75
16	$1\frac{1}{8}$	100	68	74	79	121	76
17	$1\frac{1}{8}$	100	68	75	81	132	71
18	$1\frac{1}{8}$	100	69	76	82	142	76
19	$1\frac{1}{8}$	100	70	78	85	155	93
20	$1\frac{1}{8}$	100	70	79	83	159	71

TABLE II.

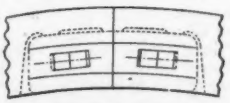
Thickness of Plating in 20ths of one Inch.	Dia. of Rivets in Inches.	Breadth of Lap in Inches.	Number of Rows of Rivets.	Spacing of Rivets Centre to Centre in Inches. Endmost Rows.	Inner Rows.	Strength —Percentage of Solid Plate.	Extra Rivets for Butt under Compression per Space in Endmost Row Rivets.
5	$\frac{5}{8}$	$4\frac{1}{2}$	2	$2\frac{1}{2}$	—	62·2	$\frac{1}{2}$
6	$\frac{3}{4}$	5	2	3	—	62·4	$\frac{1}{2}$
7	$\frac{7}{8}$	5	2	3	—	62·5	1
8	$\frac{7}{8}$	$7\frac{1}{2}$	3	$3\frac{1}{2}$	$3\frac{1}{2}$	65·8	1
9	$\frac{7}{8}$	9	3	4	4	65·6	1
10	$\frac{7}{8}$	9	3	$4\frac{1}{2}$	3	66·8	1·15
11	$\frac{7}{8}$	11	4	$4\frac{1}{2}$	$4\frac{1}{2}$	68·0	1·25
12	$\frac{7}{8}$	11	4	$4\frac{1}{2}$	$3\frac{5}{8}$	68·8	1·3
13	1	$12\frac{1}{2}$	4	5	$4\frac{1}{2}$	67·5	1·17
14	1	$12\frac{1}{2}$	4	$5\frac{1}{2}$	$3\frac{1}{2}$	68·3	1·3
15	1	$12\frac{1}{2}$	4	$5\frac{1}{2}$	$3\frac{1}{2}$	69·2	1·5
16	$1\frac{1}{8}$	$14\frac{1}{2}$	4	$5\frac{1}{2}$	4	68·0	1·3
17	$1\frac{1}{8}$	$14\frac{1}{2}$	4	6	$3\frac{1}{2}$	68 7	1·3
18	$1\frac{1}{8}$	$17\frac{3}{4}$	5	$6\frac{1}{2}$	$4\frac{1}{2}$	69·3	1 3
19	$1\frac{1}{8}$	$17\frac{3}{4}$	5	$6\frac{1}{2}$	$3\frac{5}{8}$	70·3	1·2
20	$1\frac{1}{8}$	$17\frac{3}{4}$	5	$6\frac{3}{8}$	$3\frac{1}{2}$	70·2	1·5

Fly-wheel Rim Joints.

Among the principal forms of rim joints are those illustrated in Fig. 1, and the following points should be observed: In flanges or bolted joints (*a*) the bolts should be as near the rim as possible, and should be carefully fitted at each end and cleared in the centre, so that the stress on them may be tensile rather than shearing. They should all be initially stressed by screwing up, if possible, to the same amount. In the dowel-plate and cotter joint (*b*) accurate machining and fitting are most important. The strength of the cast-iron cotters, and portion of the dowel-plate in shear should be equal to the strength of the portion of the dowel-plate in tension. The accuracy with which

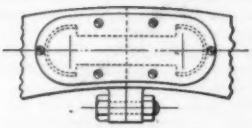


FLANGED AND BOLTED
a

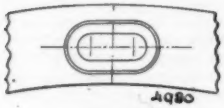


DOWEL PLATE AND COTTERS
b

FLYWHEEL JOINTS.



ARROW HEADED BOLTS
c



LINKS AND LUGS
d

FLYWHEEL JOINTS.

the initial stress in this form of joint can be adjusted is an important feature in its favour. In the arrow-headed bolt joint (*c*), which is a shrunk joint, the points to be attended to are accurate machining between the luts on the bolts and rim and provision for clearance at the centre, for the same reason as noted in *a*. In the link-and-lug joint (*d*), which is also a shrunk joint, the lug should project, as shown in the figure. The increase of weight which such a form necessitates is a good reason for removing the position of the joint nearer one arm. Where practicable, cast-iron fly-wheels should have one-piece rims; but when jointed the best form is the link-and-lug type, where such can be adopted without inconvenience, and the next best is the dowel-plate and cotter. Flanged and bolted joints should be avoided, and the best place for a joint is near one arm.—**W. Burlingham,** *Machy., June, 1903*, pp. 521, 522.

TABLE SHOWING RESULTS OF TESTS OF BURSTING SPEED OF EMERY WHEELS.

No. of test.	Grade mark.	No. of emery.	Speeds—Working—Revs. per min.	Speeds—Working—Feet per min.	Speeds—Bursting—Revs. per min.	Speeds—Bursting—Feet per min.	Speed ratio.	Factor of safety.
1	4.5	20	1,200	5,030	3.100	13,000	2.58	6.67
2	4.5	20	1,200	5,030	3,200	13,400	2.67	7.14
3	4.5	20	1,200	5,030	3,350	14,020	2.79	7.73
4	Q	30	1,250	5,230	3,750	15,700	3.00	9.00
5	Q	30	1,250	5,230	2,750	11,500	2.20	4.84
6	H	30	1,400	5,870	4,550	19,050	3.25	10.56*
7	H	30	1,400	5.870	4,600	19,200	3.28	10.76*
8	O	36	1,250	5,230	4,100	17,200	3.28	10.76
9	O	36	1,250	5,230	4,125	17,250	3.30	10.89
10	2.5	60	1,150	4,830	2,750	11,500	2.39	5.71
11	2.5	60	1,150	4,830	2,900	12,100	2.52	6.35
12	M.H.	14	1,200	5.030	3,100	12,970	2.58	6.66
13	M.H.	24	1,200	5,030	3,800	15,900	3.17	10.00
14	H	10-12	1,200	5,030	4,100	17,200	3.42	11.70†
15	H	10-12	1,200	5,030	4,350	18,200	3.62	13.10†

*Wire netting. †Vulcanized rubber.

The Bursting Speed of Emery Wheels.

THE object of the experiments described by the author was to determine the bursting speed of emery wheels such as are actually on the market. Wheels are obtained through various outside parties without indicating to the manufacturers the use to be made of them. The following table shows the results of the experiments in detail.

An examination of the last two columns in the table shows that the wheels burst at speeds varying from two and one-quarter to three and three-quarters the working speed, and accordingly had factors of safety varying from 5 to 13. At the same time, considering the violent nature of the service and the shocks to which they are exposed, a factor of 8 or 10 would seem small enough. It is a fact worthy of notice that in nearly every instance the cracks radiated from points where the lead bushing projected into the body of the wheel. —**Prof. C. H. Benjamin,** *Eng. News, Vol. XLIX., No. 26*, pp. 571-572.

APPLIED ELECTRICITY.

Electricity for Hospitals.

WHERE electric energy is simply used for lighting, the generating set ought to be quite separate from the engine employed for driving machinery, and the installation of a battery permits the storage of electricity during the day when steam can conveniently be spared. In cases where energy is applied both for light and for power, the battery can be slowly charged throughout the day, and used (either alone or in conjunction with the generator) for carrying the evening load. As the voltage required for charging a battery is about one-third more than the normal voltage, it is evident that some means of adjustment must be provided if charging is to be conducted while the generator is being used for other purposes. The most satisfactory method is to add a machine of the type known as a "booster," which is capable of raising the voltage of current from the ordinary circuit to the voltage necessary for charging. As in special cases where highly fluctuating loads occur, owing to the sudden starting of machines absorbing considerable amounts of power for a few moments, a booster can be applied in connection with a small regulating battery, and so connected that the average current of the variable load may be supplied as a constant load, the battery being charged while there is little or no demand for power, and discharged heavily when the momentary strain comes on; thus adding to the normal supply from the booster sufficient current to meet the augmented demand. Such an arrangement prevents injurious shocks in the generating set, and various unsatisfactory disturbances of the service generally. For the purpose of affording a basis for calculation a small plant station, recently equipped under the direction of the author, is

taken as an example. The capacity of the plant is 10 kilowatts, and the cost was 575*l.*, the annual output for light alone being about 8,000 B.T.U. If made available for power as well as for light the capital expenditure would be raised to 675*l.*, and the output would be 23,000 B.T.U.

TABLE I.—COST OF ELECTRICAL ENERGY IN HOSPITAL INSTALLATION IN PENCE PER B.T.U.

Items.	Light only.	Light and Power.
Fuel	·80d.	·80d.
Water and Engine Room Stores	·07d.	·07d.
Attendance (extra) ...	·55d.	·20d.
Maintenance	·75d.	·37d.
Works Cost ...	2·17d.	1·44d.
Repayment and Interest	1·20d.	·50d.
Total Cost ...	3·37d.	1·94d.

TABLE II.—COST OF ELECTRICAL ENERGY IN HOSPITAL INSTALLATION IN PENCE PER B.T.U.

Motive Power.	Cost of Production.			
	Light only.		Light and Power	
	Works Cost.	Total Cost.	Works Cost.	Total Cost.
Steam Engine; coal at 15s. per ton	2·17	3 37	1·44	1·94
Gas Engine; gas at 2s 6d. per m. c. ft. ... Consumption, 30 c. ft. per k.w. ...	2·27	3·47	1·54	2·04
Consumption, 37·5 c. ft. per k.w. ...	2·49	3·69	1·76	2·26
Oil Engine; oil at 4d. per gall...	1·97	3·17	1·24	1·74

TABLE III.—COST OF GAS AND OIL FOR DIRECT LIGHTING IN PENCE FOR A QUANTITY PRODUCING THE SAME C.P. AS ONE B.T.U. OF ELECTRICITY.

Illuminant.	Average of Various Burners	Bat's-wing Burner.	Argand Burner.	Incandescent Burner.	
				New.	At 300 hrs.
Gas at 2s. 6d. per m. c. ft.	1·55	2·61	2·30	·56	1·75
,, 3s. 0d. ,,	1·83	3·13	2·76	·67	·80
,, 3s. 6d. ,,	2·14	3·65	3·15	·78	1·05
Oil at 4d. per gall. ...	1·12	—	—	—	—

The cost of energy under both conditions is given in Table I., the average price charged by public supply corporations in Great Britain being stated at 4·47*d.* per unit. In places where steam is not required for other purposes, the internal combustion motor provides power more cheaply than the steam-engine, and one advantage it possesses is that of adaptability to intermittent work. When the engine is stopped the consumption of fuel ceases, whereas in the case of the steam-engine there is continuous waste of fuel during the intervals of work. Taking the consumption of gas at 30 c.ft. per k.w., the author finds the total cost per unit in the case selected to be 3·47*d.* for light alone, or 2·04*d* per unit for light and power. The oil engine offers another alternative to steam for the generation of electrical energy and in many parts of the country it will be found more convenient and more economical than the gas-engine. Allowing 1·2 lb. of oil per k.w., the total cost of energy from an oil-driven plant is 3·17*d.* for light, or 1·74*d.* for light and power. The results are summarised for comparison in Table II., and in Table III. the relative costs of gas and oil for direct lighting are compared with the cost of electricity.

The following conclusions are drawn by the author:—(1) That electrical energy can be generated in a hospital of moderate size at a cost considerably lower than the average rate charged by public supply corporations. (2) That economical production is greatly aided by utilisation of the generating plant for power as well as for light. (3) That under favourable conditions energy can be generated at such cost that electric lighting becomes less costly than direct gas lighting when ordinary burners are employed, although more costly than gas lighting by incandescent burners, and more costly than direct lighting by oil lamps.—**W. Noble Twelvetrees,** *Jnl. San. Inst., Vol. XXIV., Bradford Congress, Sec. II., 1903.*

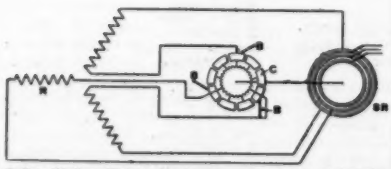
Induction Machines and a New Type of Polyphase Generator.

In this article the writer gives a short account of a new type of Polyphase Generator designed by Mr. Alexander Heyland, together with some remarks relative to its development. Although synchronous, the operation of their field systems is of the nature of that of asynchronous machines. These generators are self-exciting, and are scientifically and properly compounded, not only with regard to the magnitude of the current, but with regard to its phase-difference, a result never before attained with synchronous machines. The problem solved by Mr. Heyland is the production of the magnetic flux of the motor by means of very

low-frequency magnetising currents, and the principle involved is as simple as it is ingenious and effective. What Mr. Heyland does is to produce the magnetic flux of the motor by means of magnetising currents in the rotor. These currents are led into the short-circuited rotor winding from the outside by means of a special commutator, the function of which is to convert the high-frequency current into current of very low frequency, according to the slip of the rotor. This low-frequency current, circulating in the short-circuited rotor bars, furnishes the ampère-turns required for the production of the magnetic flux of the motor, and the current thus tapped off from the line is led into the short-circuited rotor in such a way that it has in the rotor exactly the same direction and phase as the magnetising current in the stator which it replaces. Fig. 1 shows one way of doing this for the case of a slip-ring motor. Until the advent of the Heyland compensated induction motor, the asynchronous, polyphase generator had met with no application in practice, notwithstanding its inherent valuable properties. The induction generator, with the addition of the Heyland compensating arrangement, becomes at once a commercial possibility, for in the first place, it is self-exciting, and in the second place, it can be loaded inductively. All that is required is a quite small synchronous machine on the same circuit to fix the frequency—a requirement in no way objectionable in, for instance, a power station. But the most interesting feature of the compensated induction generator is that it can be readily compounded or over-compounded for inductive loads. By passing the main current, or a proportion of it, through the short-circuited rotor, in addition to the compensating current, the machine can be arranged to give a constant pressure at its terminals independently of the amount of the phase difference of the load, or it can be made to compound up as desired. Fig. 2 shows one way of doing this, the same brushes being used for the compounding current as for the compensating current. The former is provided by a small current transformer, as shown, and the latter by a pressure transformer. The resistance shown in the exciting circuit is for adjusting purposes only, taking the place of the shunt resistance of a continuous-current generator; the compounding is adjusted also in an analogous method, with the help of a diverting resistance in parallel with the brushes, or by altering the number of turns on the current transformer, or by both means. By making use of three separate brushes for the compounding current the size of both transformers can be reduced, and the resistance in the compensating circuit becomes unnecessary.—**A. C. Eborall,** *Electrician, July 3, 1903,* pp. 442-444 and 486.

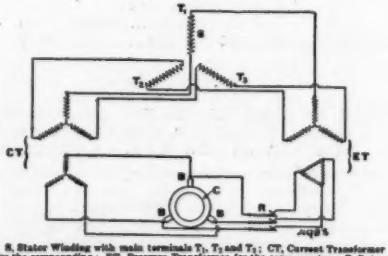
Economy in Continuous-Current Dynamo Design.

Some time ago it occurred to the writer that this problem of how to reduce the cost of construction of dynamos without sacrificing efficiency, could be to some extent solved by the methods of analysis, and he found that such was the case. Both in the case of the armature and the field-magnets, the current density in the conductors and the necessary surface for radiation are taken as the basis for investigation. The field-magnets are first considered, and having found the values of *nl (number of turns on field magnets × length of perimeter of magnet core)* for two cases, where mild cast-steel and wrought-iron were used for the cores, the writer shows that the values of *nl* were respectively 18,400 ÷ *v* and 15,000 ÷ *v*; where *v* = leakage coefficient. The values of *nl* in the two cases were thus in the ratio, 1 : 0·92. Hence there is a slight economy of copper when steel is used, and the steel is cheaper and easier to work than wrought-iron. Turning next to the armature, the writer arrives at the best value for the diameter. The method of determining *g (the length of gap space)* depends upon the way in which the armature is wound. If the conductors are embedded,



R, Rotor Winding; SR, Rotor Slip-rings for starting resistance; C, Rotor Commutator with connected segments; BBB, Commutator Brushes directly or indirectly connected to the supply conductors.

FIG. 1.—ARRANGEMENT OF ROTOR OF COMPENSATED THREE-PHASE SLIP-RING MOTOR.



S, Stator Winding with main terminals T_1, T_2 and T_3; CT, Current Transformer for the compounding; ET, Pressure Transformer for the compensation; C, Rotor Commutator with brushes BBB; R, Regulating Resistance in the compensating circuit. The stator windings and commutator connections are not indicated.

FIG. 2.—COMPENSATING AND COMPOUNDING ARRANGEMENTS FOR A SELF-EXCITING AND COMPOUNDED ASYNCHRONOUS GENERATOR.

INDUCTION MACHINES.

or are wedged between teeth, the iron between not being in the least saturated, g is merely the clearance necessary for mechanical safety between the external surfaces of the armature and pole faces. But if it is thought desirable, in order to reduce sparking, to make the iron between the conductors highly saturated, the radial depth of each conductor and permeability in the iron between the conductors must be considered. It will be found quite possible to keep the iron between the conductors quite unsaturated if the latter are of long copper strip. The question may be asked whether, in order to reduce sparking, it is best to increase the gap space or to use a compensating device such as that of Prof. Ryan. This question is very easy to answer, for in order to reduce sparking by increasing the gap it is necessary to give it a length at least four times as great as it need have for purposes of clearance. Hence the amount of copper used in the field winding (and also in the armature) will be doubled, and twice as much copper will be used in the whole design. But if Prof. Ryan's device is used, complete compensation can be effected by using as much copper in the polar coils as is used in the armature. Therefore, one-and-a-half times as much copper will be used in the whole design. It is clear from this that great economy is effected by using the polar compensating coils. It also seems probable that fewer coils than the number required to produce complete compensation might be sufficient to reduce sparking. Undoubtedly, then, it is a very bad plan to reduce sparking by saturating the teeth, and a still worse plan to do so by employing a surface winding.—**L. P. Purton,** *Electrician, June 5th, 1903,* pp. 292—294.

Supporting and Conducting Inside Conductors.

In exposed positions the conductors must be rigidly supported by a substance which will withstand rough usage, and they should be protected from moisture. Lack of flexibility, interior roughness, difficulty in preventing damage to wires in drawing in, and deterioration of cables owing to internal moisture are some of the principal objections to gas barrel.

Screwing is another source of danger, as the oil used is apt to get on to the cables and to play havoc with rubber coverings. The sharp edges left after screwing are also likely to puncture the insulation. To avoid moisture the wires should be lead covered, or enclosed in some other watertight covering. Welded steel tubing overcomes the difficulties due to roughness, but other disadvantages arise and the author advocates the use of "armoured cables." In ordinary positions, dampness and corrosive salts in plaster often cause much trouble. The author has found any form of split tubing without watertight joints very unsatisfactory. Welded steel tubing, with screwed unions, appears to give the best results, and the cables should be drawn in after the tubing has been fixed complete. Steel brazed-joint tubing has not been found satisfactory. Non-waterproof wood casing should never be used, and bitumenised fibre tubing is apt to become pulpy in damp positions. In unexposed positions wood casing is regarded as equal to many materials used in interior wiring. Split tubing has not much to recommend it, except that it can be fixed by less highly-paid men than can fix wood casing. In the author's opinion lead-covered cables are much better than wood casing or tubing. The average cost per point of inside wiring is given in the following table:—

APPROXIMATE COST PER POINT SINGLE LIGHT WIRING INSIDE BUILDINGS:—

Method.	Materials.	Labour.	Total.
Iron gas-barrel ...	13 0	12 6	25 6
Screwed welded tubing	13 6	10 0	23 6
Armoured cables ...	9 0	8 0	17 0
Insulators	6 5	5 2	11 7
Painted wood casing	7 6	6 0	13 6
Ordinary wood casing	6 7	6 0	12 7
Split steel tubing ...	7 0	6 0	13 0
Lead-covered wires (clipped direct) ...	5 9	4 6	10 3
Insulators (cleat type)	5 6	3 9	9 3

O. L. Falconar, *Jnl. I.E.E., Vol. XXXII., Pt. 4, No. 162, June, 1903,* pp. 835–852.

The Prevention of Electrically-Deposited Dust.

When current is supplied "continuous," and when one wire is earthed, and the voltage is above 200, dust gathers in quantity in the vicinity of all flexible conductors, at one of the poles of the main switch and on the distribution boards. The lamps, too, have their period of efficient light shortened by the accumulation of sticky dust on the outside surface. Taking an ordinary city installation fed by three cables, of which the centre one is earthed, it will be observed that the slabs on which the positive and negative poles of the main switch are mounted are uniformly dusty, while the slabs on which the earth-connected brasswork is mounted remain clean. If a circuit be traced, the dust marks are not often objectionable until the flexible conductors are reached, but most private houses and offices have a considerable number of yards of "flexible" in use. When it is led across a wall or ceiling in such an installation, the surface soon becomes strongly marked with a broad black line, which is unsightly and permanent. The silk braiding also gathers an amount of dust which, in ordinary circumstances, would be out of all proportion to its collecting area. It seems evident, then, that a number of the small particles of suspended matter are floating in the air approximately at earth potential. They are drawn towards the outer wire, be it positive or negative, and those particles which are firmly caught and held in the small hairs of the braiding, are in time projected against, as well as attracted by, the walls or whatever happens to be near. In ordinary circuit wiring, the comparatively thick dielectric on the

taped and case conductors minimises the collecting property, and the nuisance is kept within bounds. I do not see how it is possible to prevent the dust accumulating on high-voltage lamps, unless the bulbs are washed fairly often. Flexible wire is the most troublesome, but the trouble would va ish if the flexible were made concentric and connected with the earth-wire outside. The outside conductor would, of course, have to be insulated to come within the rules of supply companies.—**D. S. Munro,** *Elec. Rev., Vol. LII., No. 1,332,* pp. 984-985.

Galvanising Iron by Electrolysis.

THE employment of electrolysis for the deposition of zinc upon iron has already been adopted for some years in Europe and America, but this industry has not developed to any great extent. Its slow development is attributed to the extreme care necessary for obtaining deposits uniformly clean and adherent on objects of irregular form. Not only must the object be perfectly clean and free from greasy matter, but it is also necessary that the concentration, the temperature, and the purity of the zinc solution should be rigorously regulated. It is equally necessary to use electrodes of special form for many articles. Moreover, the density of the current and the electro-motive force require considerable attention, from the point of view of uniformity. The fact that the electro-galvanising process is employed in industry, in spite of its inconvenient features, demonstrates sufficiently that it offers important advantages; and, moreover, Messrs. Krupp have installed a plant for the process at Gaarden. A recent improvement, making it possible to increase the output, has been patented by Paweck (brev. Fr. No. 318,613), in which the inventor proposes the employment of boracic acid and of borates in the bath, mixed with ammonium sulphate or other alkaline salts. The objects to be galvanised are introduced in a perforated cylinder, which is mounted upon a horizontal shaft in such manner that they will be turned in the electrolyte, remaining in contact with the negative pole. Articles of comparatively large dimensions are suspended in the bath, the anodes being disposed on a vertical shaft In either case the object is to circulate and to mix the electrolyte. The only new features of the invention consist in the use of boracic acid, or borates, the employment of perforated revolving cylinders and agitation of the electrolyte having been practised for many years.—**Ad. Jouve,** *L'Electricien, Tome XXVI., No. 653, 2nd Series, July 4, 1903,* p. 12.

The Telegraphone.

THIS apparatus, invented by the author, as is known, is a phonograph, recording sound waves by an electro-magnetic means on a steel wire spiral or strip wound on a cylinder. The telephonic currents, produced by a microphone, are led to an electro-magnet, in front of the poles of which there moves the above spiral or strip, the relatively weak currents exciting magnetism in the different parts of the steel wire as the latter passes by. As this magnetism is permanent, language may be fixed by this means. When the words recorded are to be reproduced, it suffices to run the above steel wire in the same direction in front of a similar electro-magnet, to the windings of which a telephone is connected. As the different parts of the wire show differences of magnetism, there will, in the windings of the electro-magnet, be produced corresponding induction currents, which in turn will act on the telephone. The author gives an account of the improvements made in connection with his apparatus since the appearance of the first type, as well as of the hopes he attached to the telegraphone. The fact that a somewhat intense respiration will easily be recorded and reproduced by the apparatus is illustrative of the sensitiveness of the latter. In the latest type of apparatus the cylinder is replaced by a round and thin steel disc, which may easily be put into an envelope and sent anywhere in order to be reproduced by another apparatus. As a comparatively large amount of writing may be recorded on the unit of surface of these plates, the apparatus may, if desired, go on talking for a long time. Many thousands of reproductions may be made, without their being weakened to any appreciable degree. Moreover, many copies may be taken of the language recorded. These apparatus will be brought out very shortly.—**V. Poulsen** (Paper read before the Copenhagen Industrial and Hygienic Congress), *Elektrotek. Tidsskr., 16, No. 21, July 25, 1903,* p. 136—*A.G.*

Wind-Power for Electric Central Stations.

THE author has, on behalf of the Danish Government, made a series of experiments with windmotors used to drive electric plants, the results affording a satisfactory solution of the problem. The difficulty experienced in imparting to the motors an approximately continuous speed, independently of the strength of the wind, was solved by the use of an intermediate shaft placed in connection with a balance; the belt from the mill is led vertically on to the disc of the intermediate shaft, its pressure on the latter being regulated by the balance bearing convenient counter-weights; from the intermediate shaft another belt leads on to the dynamo. This arrangement will result in the belt from the mill sliding on the disc as soon as the load exceeds a given maximum; the number of revolutions of the dynamo will therefore remain constant within certain limits, while the mill may be run at any speed. By means of this arrangement—in connection with a maximum and minimum interrupter that automatically switches the machine in as soon as the tension has reached a convenient value, and cuts it out again when the wind becomes too weak—the author has obtained excellent results, the plant having worked satisfactorily even with the strongest storms. Storage batteries will, of course, always have to be resorted to in plants of this kind, one of which has been operated with excellent results, since October, 1902, at Askov, Denmark, feeding about 450 installed glow lamps, while another is being built in Vallekilde. Petroleum motors are installed, to serve as a reserve in cases

of several days' calm weather.—**P. La Cour,** Paper read before the Copenhagen Technical and Hygienical Congress; See *Elektrotek Tidsskr., Christiania, 16, No. 21, July 25th, 1903,* pp. 136, 137.—*A.G.*

Method of Measuring the Moment of Inertia of the Armature of a Dynamo.

INTERESTING results with regard to the friction in the bearings, as well as the air and brush friction [see Abstract of Dr. Finzi's article, p. 279] may be derived from a study of the spontaneous retardation of a motor running with no load, the driving couple being eliminated. In order, however, to make these calculations possible, the moment of inertia of the armature should be known. As the methods so far used in obtaining this important factor are both troublesome and uncertain, the author suggests a novel method based on an investigation of the spontaneous retardation of the armature, the exciting current being kept on. After having constructed a table giving the current i in the armature for different values of the angular velocity, the time T required to pass from the speed Ω to speed zero is found to be

$$T = \frac{\kappa}{\alpha} \int_{0}^{\Omega} \frac{d\omega}{i}$$

where α is a + constant and κ the moment of inertia. The curve having the different values of ω as abscissæ and those of $\frac{1}{i}$ as ordonates is drawn, and the area measured by means of a planimetre, when the above equation will give the value of κ. A simpler expression is found for the frequent case of i being a practically linear function of ω, when any graphical construction may be dispensed with.—**Ch. Fabry,** *Écl. Élec. XXXV., No. 22,* pp. 321-324, *May 30, 1903.*—*A.G.*

On the Theory of Electric Batteries.

FROM a study both theoretical and experimental the conclusion is arrived at that every electro-chemical couple, being based on a chemical reaction, will possess a theoretical capacity limited by the equilibrium constant of the system, as the reaction tends towards a well-defined state of chemical equilibrium instead of a total transformation. It, accordingly, is utopian to hope ever to obtain the total capacity as corresponding to Faraday's law. A further limit is opposed by the velocity of reaction, reducing to a still higher degree the practical output of the battery. The author thinks systems of a high e.m.f. to be most likely to yield a satisfactory output, as the rate of reaction increases with the thermic character of the latter, and, thus, with the e.m.f. itself, according to a parabolic law; the lead accumulator, therefore, is considered as affording the best means of methodical researches in the field of storage batteries. The battery of the future, however, as maintained by the author, will be a primary circulation battery, as, according to a formula derived, a state of equilibrium with constant electro-motive force will be produced by renewing the reacting products and taking away progressively those formed by the reaction. The author accordingly suggests designing "electro-chemical gas burners" which would transform the heat of combustion directly into electrical energy, in a complete way and with a practically total utilisation, avoiding the thermal motor with its low theoretical output, as well as the present electro-chemical reservoir, the utilisable capacity of which is so reduced by the above theoretical facts.—**G. Rosset,** *Écl. Élec. XXXV., No. 22, May 30, 1903,* pp. 324-344.—*A. G.*

Electrolytic Production of Vanadium and its Alloys.

THE principle of my process rests on the great conductivity of vanadium trioxide, and on the facility with which vanadium trifluoride is obtained in acting upon the trioxide by fluorine in the presence of carbon. To show how these characteristic properties may be utilised, let us assume the electrolysis of ferrous fluoride in solution with calcium fluoride, making use of an anode formed of an intimate mixture of vanadium trioxide and carbon, the cathode being constituted of metallic iron. The ferrous fluoride being decomposed by the current, the fluorine liberated at the contact of the anode attacks the vanadium trioxide, which yields up its oxygen to the carbon so as to form vanadium trifluoride according to the reaction:—

$$6F + V_2O_3 + 3C = 2VF_3 + 3CO.$$

The vanadium fluoride formed is electrolysed in turn: $2VF_3 = (2V + 6F)$. The vanadium set at liberty at the cathode combines with the metallic iron liberated at the anode; it forms a new quantity of vanadium fluoride, which is electrolysed in such manner that the ferrous fluoride assists the operation to furnish fluorine, which serves as a vehicle for passing the vanadium from the anode to the cathode. Having thus explained the theory of his process, the author describes its application in practice. In addition to the production of vanadium, the process is applicable for producing alloys with metals such as copper, aluminium, and manganese. It is only necessary to replace the cathodic bath of iron by a bath of the metal to be represented in the alloy.—**Gustave Gin,** *Proc. Cong. Int. de Chem., Sec. X., Berlin, June, 1903.*

Separating the Losses by Friction in Electrical Machines.

OUT of the different items the loss by friction in electrical machines is made up of, only the one corresponding to brush-friction has so far been adequately dealt with. The air- and bearing-friction, on the other hand, are, as a rule, considered jointly, assuming the former to be only a few per cent. of the aggregate friction. This hypothesis, however, as pointed out by the author, is generally far from being true, especially with modern machines, designed with a view to

obtaining good ventilating effects. The author, accordingly, describes some methods of separating both frictions. As the effect of bearing-friction is inversely proportional to the temperature of the bearings, whereas that of air-friction is, of course, independent of that temperature, the total loss by friction, deducting the item due to brush-friction, may be presented by an equation of the form—

$$R_{(t)} = a + \frac{C}{t}.$$

Both constants are easily determined by combining a series of observations and either solving systems of two equations each or drawing the straight line represented by the equation. A simpler method is based on the hypothesis that the resistance of air is proportional to the square of the speed, the coefficient of friction being proportional to the square root of the latter. Both methods may be used jointly, so as to check one another.—**Dr. L. Finzi,** *Elektrot. Zeitschr. XXIV., No. 28, July 9th,* pp. 536–537.—*A.G.*

A Break not a necessary part of the Induction Coil.

It is frequently said in comparing static machines with coils for exciting X-light tubes that the defect of the coil is the break, which makes the light unsteady. Those who make this criticism forget that a break is not an essential part of an induction coil. One reason why I advocated coils of high potential for exciting X-light tubes was that such coils did not need a break, for by using an alternating current in the primary it was practicable to develop sufficient potential in the secondary to excite an X-light, even though it had a low resistance. I believe Spottiswoode was the first to prove that a coil could be operated in this way for vacuum tube work. In 1879 he showed that a twenty-inch coil could be employed with an alternating current from a De Meritens dynamo in the primary. The spark from the secondary was 7 ins. long, the size of a cedar lead pencil, extremely steady and suitable for spectrum work without a condenser in the secondary.—**W. Rollins,** *Elec. Rev. (N.Y.), Vol. XLII., No. 26,* p. 917.

WATER AND SANITARY.

The Scott-Moncrieff System of Sewage Treatment.

There is ample information available for the construction and management of resolving tanks, and this part of the bacterial process is removed from the debatable region of experiment. On the question of aërobic filtration, the author maintains that, wherever the percentage of oxidised to unoxidised nitrogen in an effluent is as high as the water of the Thames above the in-take of the water companies, it is safe to ignore other conditions; and that where such a ratio exists, other substances may be safely disregarded. In order to successfully design bacterial plant for the purification of any particular sewage it is necessary to know the best period during which anaërobic fermentation should be carried on, as upon this information alone can the proper dimensions of the tanks be stated with confidence. The quantity of air must be known, that is necessary for oxidising organic matter. When the proper period of anaërobic fermentation and the proper quantity of air have been ascertained, it is necessary to know the proper depth of filter; the optimum quantity of liquid for each discharge must be ascertained; and the proper period of rest between each discharge must be found by actual experiment. The object of this paper is to show how a knowledge of these factors can be ascertained, and the author refers to the air factor as one that is usually disregarded and left to the chapter of accidents. He afterwards deals with the case of an engineer who is called upon to design nitrifying filters for a particular sewage, and describes the testing apparatus and the manner in which it is to be used, so that the plant can be designed with an absolute certainty of results corresponding to those obtained from the test apparatus.—**W. D. Scott-Moncrieff,** *Proc. Incorp. Assoc. Mun. and Cty. Eng., 1903.*

WORKS MANAGEMENT.

Graphical Daily Balance in Manufacture.

At the December meeting in 1902, the writer presented a paper entitled "A Bonus System of Rewarding Labour," in which was given an account of the results gotten under that system at the works of the Bethlehem Steel Company, and a description of the method employed. The paper dealt particularly with the method of setting a task and the reward for its accomplishment. It consisted briefly in setting as a task for a day's work the amount that a good man could reasonably be expected to accomplish, and paying the man a substantial amount in addition to his day's wages if the whole task was done. If less was done he simply got his day's wages. The result of this system, when the task was set in an intelligent manner and accompanied by a suitable compensation, was an efficiency of operation so far beyond that obtained by the ordinary day or piecework method that it attracted a great deal of attention. The routine operation of the system, which involves keeping an exact daily record of the work done, was not, however, so clearly explained, and it is to that subject that this paper is devoted.—**H. L. Gantt,** *Trans. Am. Soc. Mech. Eng., Vol. XXIV., June 1903.*

The Stores Ledger.

A stores ledger implies the organisation of a stores department and the arrangement of stores in such fashion as to prevent waste or theft. There are three general schemes for keeping stores ledgers, *i.e.* book ledgers, loose-leaf ledgers, and card ledgers. Controversy over the relative merits of the three systems is principally between the book ledger and the card ledger, as the loose-leaf device contains most of the defects of the book, and almost none of the advantages of the card system. The book limits the space allotted to any item, whether the allotment is large or small. It fills up unevenly; stocks to which small space was allotted

suddenly demand large space, and cause confusion. The entire book becomes so full as to necessitate starting a new one, and then all the work of laying out the scheme must be done over again. The pages arch near the point where they enter the binding, making it hard to post neatly and accurately. The sole advantage which the loose-leaf ledger has is that it is perpetual. New leaves can be added and old ones taken out; but the loose-leaf idea has disadvantages of its own. To secure economy of space, these books are allowed to grow very thick; they therefore grow clumsy and the speed of posting in them decreases. The card system affords a means of simple and rapid classification of material in laying out the original scheme. The space allotted to each item is very small till larger space is needed, and yet it is always large enough, for new cards may be inserted and filled cards may be removed instantly whenever occasion arises. At the same time, it is easier work and faster to post on cards than in a book. The form of a card reproduced in the figure is suggested as being a good one.—**F. B. Johnson,** *Amer. Machst. Vol. XXVI., No. 25, July 4, 1903,* pp. 884-885.

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THE STORES LEDGER.

MISCELLANEOUS.

Scientific Results of the Munich Refrigerating Trial Station.

As the above trial station last year concluded its activity the author gives a *résumé* of the work done in connection with problems of universal interest. The paper is divided into four parts, the first of which deals with some experiments on an ammonia-compression refrigerating machine, the results being of especial interest, as they represent the highest relative output so far obtained in connection with refrigerating machines. The efficiency shows maximum values at about —5 degs. Cent., a fact of great importance for practical applications, as most refrigerating devices are used at similar temperatures. Superheat is found to exert an influence the more favourable, as the departures from the theoretic cycle are more considerable. The second part of the article contains some remarks on the theory of carbonic acid machines which fully elucidate their conditions of working. Some experiments on nitrogen monoxide are recorded in the third part, it being shown that, on account of its physical properties, this compound is more advantageous than carbonic acid for use in refrigerating machines. The manufacture and fractionated evaporation of liquid air is discussed in the fourth chapter, special mention being made of the author's own method, which enables the least coercible gases, excepting helium, to be liquified. The only practical application capable of some development seems, however, to be the extraction of oxygen and hydrogen by fractionated evaportion of liquid air; a process recently designed allows of any amount of atmospheric air being decomposed into practically pure nitrogen and oxygen. The methods of fixing atmospheric nitrogen, as lately suggested (see Abstract of Rasch's paper, p. 178), impart a special importance to these processes.—**C. Linde,** *Zeitschr. Vers. Deutsch. Ing., XLVII., No. 30, July 25, 1903,* pp. 1071–76.—*A. G.*

Refuse Destructors.

DURING the past few years extraordinary progress has been made in the production of power from towns' refuse. The value of the heat derived from combustion varies between the limits of one-fourth and one-twelfth, with an average of one-seventh that of good coal. This production of power has been achieved by the erection of destructors on more scientific lines, and with fuller knowledge of the capabilities of air and steam blasts, and of the calorific value of towns' refuse. Steam jets, air blasts, and fans have been brought into use to hasten the combustion, and thus to increase the temperature. The steam raised is variously used, whilst amongst the methods of utilising the clinker may be mentioned the making of mortar, flags, bricks and concrete, also material for sewage and filtration, and underbedding for roads and tramways. A scheme has recently been laid out for the disposal of refuse by converting it into fuel-gas to be used in specially arranged gas-engines, for the economical generation of power. —**J. B. Massey,** *Proc. Assoc. Cleans. Supts. of Gt. Brit., Bristol Conference, June, 1903.*

Fuel and Power.

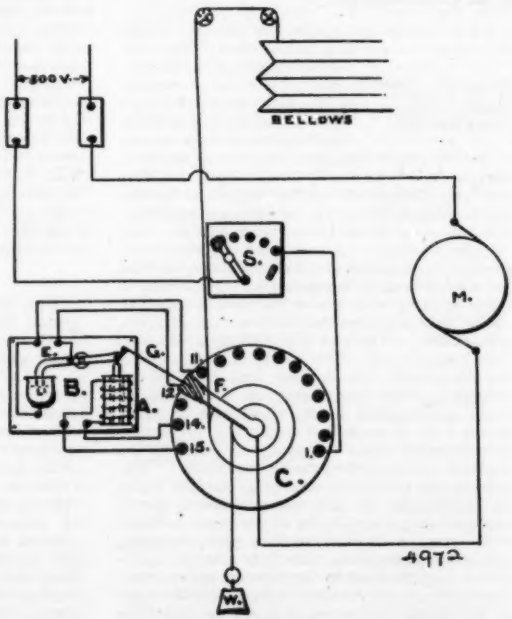
THE author discusses, by the aid of heat diagrams, the problem of recovering mechanical work from the heat of combustion according to physical conditions, in the case of the more important heat engines, and proceeds to a consideration of the centralisation of the utilisation of fuel for power, heat and lighting purposes, a utilisation in the form of centralised gasification of the fuel within generators and subsequent distribution through gas conduits embodying the most perfect solution of the problem. It would be necessary, in the case of such power transmission plants, to obtain a most high-grade gas and to be able to convey the latter both under high and low pressures to distant points and through the distribution-net.—**C. V. Linde,** Paper read before the Congress of the *Verein Deutscher Ingenieure, June, July, 1903.*—*A. G.*

WORKSHOP PRACTICE.

This supplement is set apart for the discussion of matters relating to Works Management, Tools, the Machine Shop, Foundry, Pattern Room, and General Practice, both Mechanical and Electrical. It is of prime interest to Works Managers, Foremen, etc., from whom contributions, which are paid for, are cordially invited. In addition an award of One Guinea is made for what, in the opinion of the Editor, is the best contribution of the month.

Automatic Switch for Organ Motor Controllers on 500-volt circuits.

ONE of the difficulties met with in controllers for Organ Motors on 500-volt circuits, is to prevent the destructive arcing which takes place at the last stop when the circuit is broken. Quick break switches, with carbon contacts connected to the last stop, have been tried, but as they make and break several times a minute, if the organist stops playing, or plays softly, the carbon blocks soon want renewing. Neither is there much gain in current saved, for the circuit is no sooner broken than it is made again. Some controllers do not cut off at all, but are made of such a resistance that the current is reduced below the amount required to turn the motor. This way is wasteful, for the current taken when the motor stops differs little from the current taken when the motor turns slowly. By reference to the diagram, the working of this automatic switch is easily understood. When the bellows are empty, the sliding contact *F* on the controller is on stop 1, and all resistance cut out. The motor is started by switch *S*, which also controls the shunt current of the motor. As the bellows fill, the sliding contact *F* is moved round towards stop 15 by the action of weight *W*. Directly stop 14 is passed the current flows through coil *A*, and sucking in the core attached to the movable arm *E* breaks the circuit between stops 11 and 12 by means of switch *B*. The motor stops and the bellows begin to gradually empty themselves, until stop 12, or any other determined point, is reached, when the movable arm E is tilted back by the rod G, fixed to the sliding contact F, and the circuit is again made. The circuit may of course be broken between any two stops, say 7 and 8, but it is well not to take them too far back on account of the increased current at starting again. The switch B consists of



AUTOMATIC SWITCH.

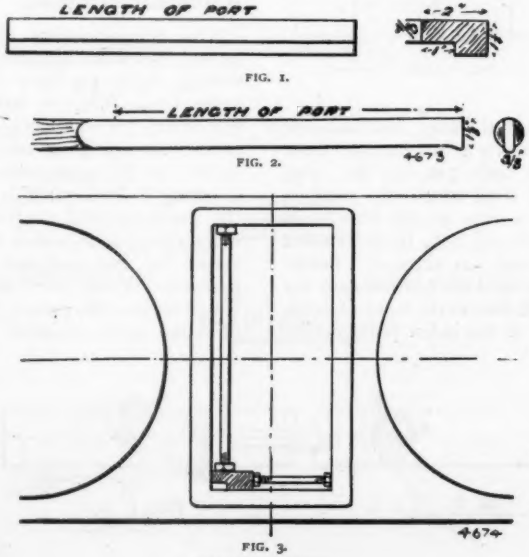
dipping arm *E* and cup. The cup is half filled with mercury, water and oil and practically no arcing takes place when the circuit is broken or made. R. C. H.

Refacing Cylinder of Steam Engine.

The valve face on the cylinder of a steam engine usually wears hollow, and in refacing it is always advisable to cut clearance both top and bottom. To do this on a double-cylinder engine where the two valves work in one steam chest between the cylinders is always a difficult matter, but by using the following simple arrangement the difficulty disappears:—Fig. 1 is a block of iron about 2 ins. by 1¼ in., shaped down its length as shown in section to form a guide for chisel bar. The bar, Fig. 2, has the end drawn down parallel so as to easily fit shaped part of guide block, the cutting edges formed as a round nose, projecting the depth of clearance required (in sketch ⅛ in.). The guide block is fixed in corner to be cut out by four stretcher bolts, as shown in the illustration, Fig. 3, and the chisel driven through by hammer blows, and as the guide supports the chisel on all sides a very satisfactory clearance groove may be cut. C. A.

Cutting Worm-wheels on a Horizontal Boring Machine.

The illustration shows how we cut some brass worm-wheels 14 in. diameter, 1¼-in. circular pitch on a horizontal boring machine, not having a worm-wheel cutting machine nor milling machine suitable for the job. When finished they answered our purpose admirably, though, doubtless, they were not quite so accurate as those hobbed out on a worm-wheel cutting machine. The blanks were first bored and turned, and then a line accurately marked across the rim indicating the tooth centre. This served as a guide to set the indexing point to whilst bolted to the angle-plate for cutting. The angle-plate was bolted down to the machine table, as shown, at a suitable angle for pitch of worm; the wheel blank was fastened to the angle-plate by the stud



SUP

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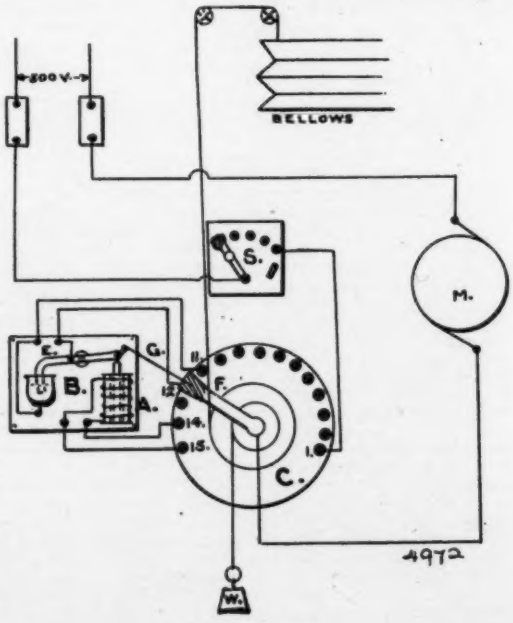
This supplement is set apart for the discussion of matters relating to Works Management, Tools, the Machine Shop, Foundry, Pattern Room, and General Practice, both Mechanical and Electrical. It is of prime interest to Works Managers, Foremen, etc., from whom contributions, which are paid for, are cordially invited. In addition an award of One Guinea is made for what, in the opinion of the Editor, is the best contribution of the month.

Automatic Switch for Organ Motor Controllers on 500-volt circuits.

ONE of the difficulties met with in controllers for Organ Motors on 500-volt circuits, is to prevent the destructive arcing which takes place at the last stop when the circuit is broken. Quick break switches, with carbon contacts connected to the last stop, have been tried, but as they make and break several times a minute, if the organist stops playing, or plays softly, the carbon blocks soon want renewing. Neither is there much gain in current saved, for the circuit is no sooner broken than it is made again. Some controllers do not cut off at all, but are made of such a resistance that the current is reduced below the amount required to turn the motor. This way is wasteful, for the current taken when the motor stops differs little from the current taken when the motor turns slowly. By reference to the diagram, the working of this automatic switch is easily understood. When the bellows are empty, the sliding contact *F* on the controller is on stop 1, and all resistance cut out. The motor is started by switch *S*, which also controls the shunt current of the motor. As the bellows fill, the sliding contact *F* is moved round towards stop 15 by the action of weight *W*. Directly stop 14 is passed the current flows through coil *A*, and sucking in the core attached to the movable arm *E* breaks the circuit between stops 11 and 12 by means of switch *B*. The motor stops and the bellows begin to gradually empty themselves, until stop 12, or any other determined point, is reached, when the movable arm E is tilted back by the rod G, fixed to the sliding contact F, and the circuit is again made. The circuit may of course be broken between any two stops, say 7 and 8, but it is well not to take them too far back on account of the increased current at starting again. The switch B consists of



AUTOMATIC SWITCH.

dipping arm *E* and cup. The cup is half filled with mercury, water and oil and practically no arcing takes place when the circuit is broken or made. R. C. H.

Refacing Cylinder of Steam Engine.

The valve face on the cylinder of a steam engine usually wears hollow, and in refacing it is always advisable to cut clearance both top and bottom. To do this on a double-cylinder engine where the two valves work in one steam chest between the cylinders is always a difficult matter, but by using the following simple arrangement the difficulty disappears:—Fig. 1 is a block of iron about 2 ins. by 1¼ in., shaped down its length as shown in section to form a guide for chisel bar. The bar, Fig. 2, has the end drawn down parallel so as to easily fit shaped part of guide block, the cutting edges formed as a round nose, projecting the depth of clearance required (in sketch ½ in.). The guide block is fixed in corner to be cut out by four stretcher bolts, as shown in the illustration, Fig. 3, and the chisel driven through by hammer blows, and as the guide supports the chisel on all sides a very satisfactory clearance groove may be cut. C. A.

Cutting Worm-wheels on a Horizontal Boring Machine.

The illustration shows how we cut some brass worm-wheels 14 in. diameter, 1¼-in. circular pitch on a horizontal boring machine, not having a worm-wheel cutting machine nor milling machine suitable for the job. When finished they answered our purpose admirably, though, doubtless, they were not quite so accurate as those hobbed out on a worm-wheel cutting machine. The blanks were first bored and turned, and then a line accurately marked across the rim indicating the tooth centre. This served as a guide to set the indexing point to whilst bolted to the angle-plate for cutting. The angle-plate was bolted down to the machine table, as shown, at a suitable angle for pitch of worm; the wheel blank was fastened to the angle-plate by the stud

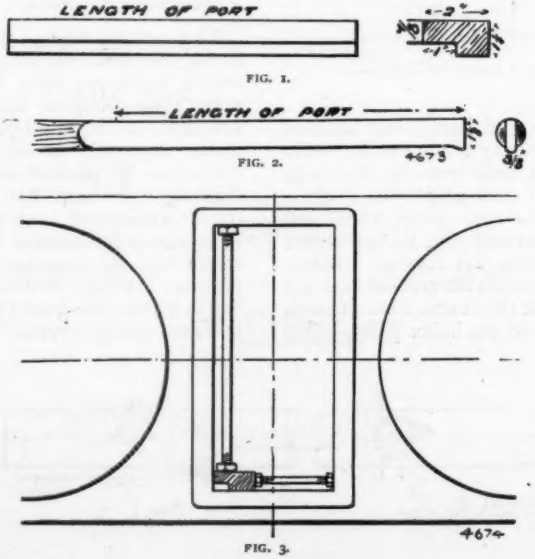
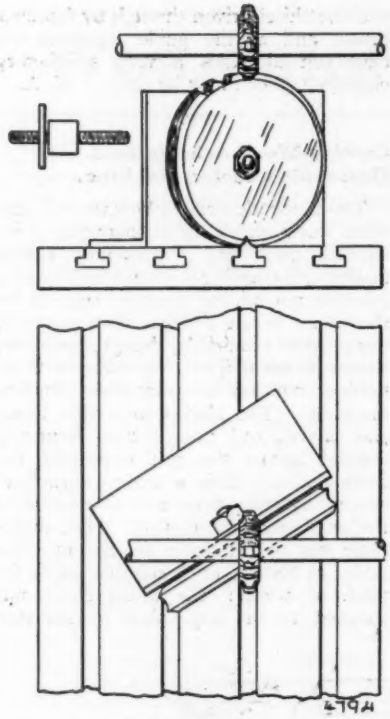


FIG. 3.

REFACING CYLINDER.



CUTTING WORM-WHEELS.

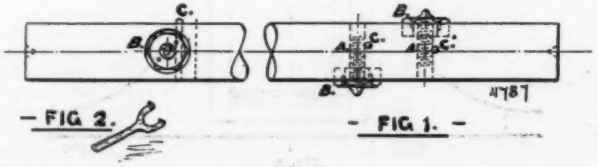
and washer, the stud being first fastened to the angle-plate by a nut on the back. The wheel was then put on the large shoulder of the stud, which was made a sliding fit to the bore of the wheel, and fastened by a nut and large turned washer as shown (the nuts not shown). Before being nipped up tight the greatest care was taken to see that the centre lines of teeth were set exactly to the index point, which was fastened to the table by a small bolt. The cutter was set exactly central over the wheel blank, and fastened on the spindle by turned bushes on each side for steadying purposes. When the spindle was started the table was gently fed up by hand to the proper depth of cut, where it was stopped by a bolt nipped up in the T-slot of the vertical slide. It was then lowered and the stud which holds the wheel slacked, and the wheel turned round one tooth until completed. Altogether twelve wheels were cut in this manner without a waster, and they are all working satisfactorily, and represent a creditable job done with an apparently unsuitable tool.

J. D.

[As the cutting of worm-wheels is a somewhat difficult job without the proper equipment, we may point out, for the benefit of our readers, that a similarly ingenious device appeared in our issue of April, 1901, applied on a different machine, and we think with a better dividing arrangement.—ED.]

Boring Bar with Adjustable Cutters.

The accompanying sketches show a boring bar with adjustable single-ended cutters which we have had in use for some time, both in lathe centres and horizontal boring-machines; it has well proved its worth, as very minute adjustments can be made with the cutters for finishing holes accurately to size without the uncertain and unsatisfactory method of knocking them with a hammer. Fig. 1 shows the bar complete with cutters in position. A hole is drilled through the bar to receive the cutters (which are made of round stock, screwed the greater part



BORING BAR.

of their length, as shown at *A*); this hole is recessed on one end large enough to allow a lock-nut, which screws on the cutters, to fit in. This lock-nut is used for adjusting the cutters, with two pin-holes drilled in the face, shown at *B*. Fig. 2 shows the adjusting key. The cutters have a flat, filed on one side to the bottom of the thread, against which the round taper wedge *C* fastens the cutter in position, it being driven through the bar in a hole drilled at right angles to the cutter hole. The cutters are very rigid when working; the adjusting nut, being well up to the cutting-point, supports it and allows heavy cuts to be taken; whilst the adjustment of the finishing cutter can be made with almost micrometral precision.

J. D.

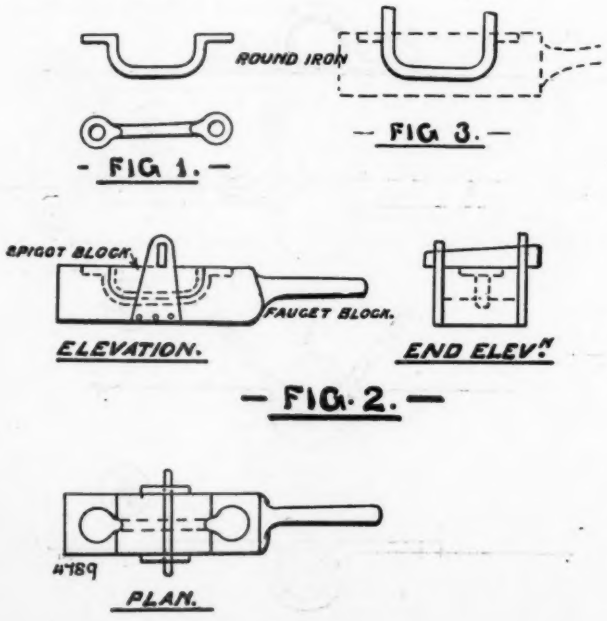
Swage Block.

The following is a simple method of making wrought-iron handles, as shown in Fig. 1, especially when a large quantity are required. Two blocks are made as shown in Fig. 2, according to the size of the handles. The material of which the handles are made is then cut up into the required lengths, and bent to the shape shown in Fig. 3. They should fit exactly into the blocks, with the allowance for making the projecting palms. The palms are then put on by heating the ends to a white heat, placing in the blocks and hammering down, using a "flatter" to smooth. The cotter is used to keep the spigot block from jumping out whilst putting the palms on. A little practice will enable one to cut the material so that nothing will need to be cut off after the swaging is finished.

ISAAC POOTS.

Pipe Clips.

Figs. 1, 2, 3, 4, show the device and method of procedure for making small



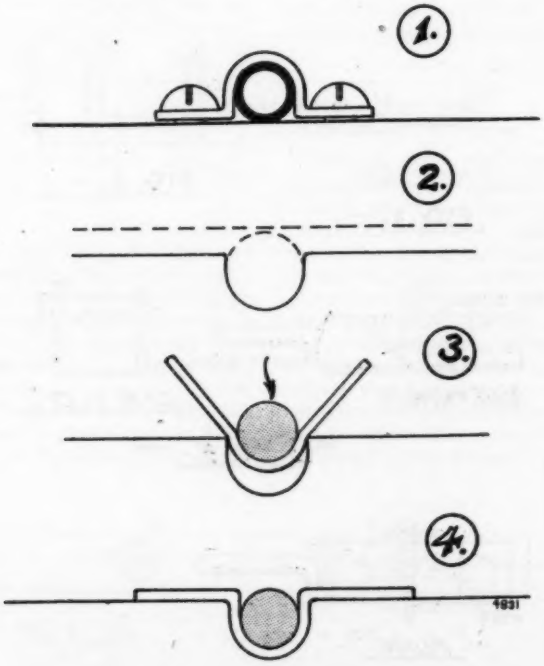
SWAGE BLOCK.

clips; Fig. 1 from sheet brass, such as would be required in fixing the lubricating pipes on small engines. A hole slightly larger than the outside of the pipe, plus twice the thickness of sheet-brass to be used for the clips, is drilled tangent to the edge of a piece of wrought-iron as at Fig. 2. The metal is then shaped away to the full line, leaving a portion of the hole as a die, into which the sheet-brass is forced either by pressure or blows on a piece of round steel placed behind it.

F. G. H.

Fixing Grindstones.

The following method of setting up grindstones may be new to some of your readers, and is the method adopted in a large engineering works in which there are a considerable number of grindstones. It has the advantage of being very easily put in and adjusted, and when fixed holds the stone securely, giving a positive drive. The stones as they arrive in the shop are about 7 ft. in diameter by 6 ins. thick, and have a round hole in centre 3 ins. in diameter. Into this hole a wooden bushing is fitted, made of beech, the outside diameter being a tight fit for the hole in the stone at the centre, but rounded over to the ends which are ¼ in. less in diameter. The hole for the spindle is 2¼ ins. in diameter and a nice fit for same. The reason why the bush is rounded on the outside in this manner is that the holes in the stones are often not square with the sides, and this allows the stones to be trued up without trouble. The spindle is fixed to the stone by means of two large plate washers, which are tightened by means of the nut on spindle. The washer next to collar is fixed to the spindle by a feather key, and



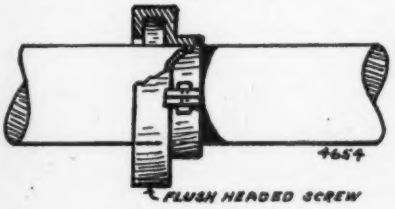
PIPE CLIPS.

has a pin fixed into it to give a positive drive to the stone. To put in place, the washer next to collar and the bushing are placed on spindle and passed through the stone, the other plate put on, and the nut screwed up. The stone is next lifted into place, and turned by hand to see if running true; if not, the nut is slightly slacked, and some small wooden wedges inserted between the washer and the stone to throw it over. This is done till the stone runs true, when any open places between the stone and the washers are filled with wedges and the nut screwed up, and the wedges dressed off. Where the stone is very uneven wooden washers may be used with the plate washers to give a better grip. The face of the stone is then trued up with a grindstone dresser. W. BURNS.

Oil Ring.

Now that high-speed engines have come to stay, great difficulty is often experienced in keeping the oil from travelling from the bearings along the crank-shaft to the rim of the fly-wheel, doing great damage to the belt, and throwing the oil over the engine-room, much to the disgust of the attendant. A brass or cast-iron ring, made in halves, bored to fit the shaft, having a cavity to receive the oil facing the bearing, and a small flush-headed screw, will allow the oil to be easily removed.

H. T. M.

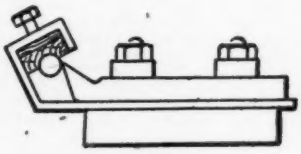


OIL RING.

A Sliding Stay.

We had a jobbing order of 24 rods to be screw-cut the full length up to 1 in. from one end. They were too long to be cut without stay, and had to be cut so near to the driver that our ordinary stays were clumsy and useless. The man who had the job went to the smithy and got a bar of 1-in. by ½-in. iron bent as shown in the sketch. A tapped hole, an iron plate, and a hard-wood step did the rest. It acted beautifully, and as a handy stay for long shafts of small diameter I think it cannot be beaten.

J. H.



A SLIDING STAY.

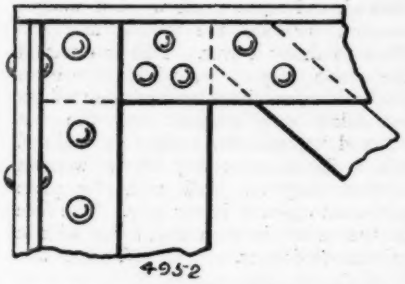
QUESTIONS & ANSWERS.

Dimensions of Gusset Plates.

Can any of your readers oblige me by telling me the usual or best way to calculate the necessary dimensions of the gusset plates connecting the various bars in a lattice girder, say, or in any framed structure where pin joints are not used? ECITTAL.

REPLY TO "ECITTAL."

It is not invariably necessary to use gusset or joint plates in a latticed girder, for, as shown in sketch, the diagonals may sometimes be simply riveted to the top flange. Everything depends upon the character and intensity of the stress. This must be calculated with due regard to dead and live loads by the usual method,* for each diagonal and each system of triangulation must be considered separately. Knowing the maximum stress, it is easy to calculate the rivet area required for connection of the struts and ties with the flanges, dividing the calculated stress by the allowable stress per square inch of rivet area. Thus, if the stress were 4·4 tons, and the allowable unit stress were taken at 2 tons, the rivet area would be 2·2 sq. ins. Hence, supposing ¾-in. rivets were used, 2·2÷0·4=5, which is the required number of rivets. The necessary space for these rivets may be provided by the width of metal in the metal forming part of the flanges, and that in the diagonals; if not sufficient, a joint plate must be used, giving such space that the rivet pitch may be in accordance with the theory of riveted joints,



and the plate must be of the thickness prescribed by the same theory.†

W. N. T.

REPLY TO Q. E. F. *Page 353, Vol. 8.*

Taking the figures in the question as being correct, we get 300 amp. × 210 volts = 63,000 watts ÷ 746 = 84·45 h.p. Assuming that the combined engine and dynamo efficiency is 74 per cent., the coal consumption must be calculated on 114 h.p. A non-condensing engine with 90 lbs. steam will consume 22 lbs. of steam per h.p. per hour. Therefore, 22 lbs. × 114 h.p. × 10 hrs. = 25,080 lbs. of steam per 10 hrs., and as a good Lancashire boiler, working under ordinary conditions, with feed water at 80 degs. Fahr., will evaporate 8·84 lbs. of water per lb. of coal, therefore 25,080÷8·84=2,837 lbs. =1·26 tons of coal per 10-hour day.

E. M. C.

* See "The Design of Structures," by S. Anglin. Griffin & Co.

† See "Structural Iron and Steel," by W. N. Twelvetrees. Whittaker & Co.